ASSESSING THE NUTRITIONAL QUALITY AND CONSUMER ACCEPTABILITY OF *MORINGA OLEIFERA* LEAF POWDER (MOLP)-BASED SNACKS FOR IMPROVED CHILDREN'S FOOD AND NUTRITION SECURITY

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ABSTRACT

Introduction

Globally, 16 million children were reported to be severely wasted, and 159 million children had stunted growth (United Nations International Children's Emergency Fund *et al.,* 2015). Nearly 2.3 million children in South Africa were undernourished with 21-48%; 8-15% and 3.7% being stunted; underweight and wasted, respectively (Gitau, 2009; Shisana *et al.,* 2013). The mortality rate of children, globally is estimated to be 3.1 million children, annually, and micronutrient deficiencies contribute to 1.1 million deaths of children. Micronutrient deficiencies or hidden hunger is mostly prevalent in Africa, specifically, Sub-Saharan Africa and Southern Asia (Weisstaub & Araya, 2008; Black *et a*l., 2013; Black *et al*., 2008).

A possible intervention could be to fortify snacks with *Moringa oleifera* leaf powder, since the consumption of processed snacks is rising in middle-income countries and in South Africa (Huffman *et al.,* 2014; Ronquest-Ross *et al.,* 2014). *Moringa oleifera* originated from South Asia, in the Himalayan foothills, located from north-eastern Pakistan to Northern West Bengal in India but now is also found in many tropics and sub-tropics of the world. (Fahey, 2005; Jideani *et al.,* 2014). *Moringa oleifera* is known as the "miracle tree" because of its nutritive value (Fahey, 2005) and according to Fuglie (2001), a 100 g of *Moringa oleifera* leaf powder contains 10 times the vitamin A of carrots, half the vitamin C of oranges, 17 times the calcium of milk, 15 times the potassium of bananas, 25 times the iron of spinach and 9 times the protein of yoghurt. The overall aim of the study was to assess whether *Moringa oleifera*-based snacks could contribute to food and nutrition security for children through the acceptability of caregivers.

Methodology

The study was conducted in Ntambanana, KwaZulu-Natal. The area is characterised by high unemployment rates and poverty (IDP, 2013/4). A mixed research method was followed, where both quantitative and qualitative research methods were used. The quantitative

research method followed the survey technique using random purposive sampling to obtain 77 caregivers with children in pre-primary school and standard methods of nutritional analysis were followed to analyse the nutritional quality of *Moringa oleifera*-based snack prototypes. Panelists for sensory evaluation were recruited during the survey and letters were also written and given to children in pre-primary schools to take home to their caregivers. Sixty caregivers were selected for sensory evaluation. Participants from the sensory evaluation were further invited to participate in focus group discussions. A series of four focus group discussions with 10-12 group members were conducted.

Results

Snacks were given to children by 87% of caregivers, daily. The kinds of snacks that were mostly given to children by caregivers were savoury snacks (73%), fruit (53%), dairy snacks (46%) and sugary snacks. The snack prototype with 5% *Moringa oleifera* leaf powder (MOLP) content was greener in colour compared to the control (0%), 1% and 3% MOLP snack prototypes. As the MOLP content increased at concentrations of 0%, 1%, 3% and 5% the breaking force of the snack prototypes decreased, meaning the texture became softer ($p<0.05$ for the control and 5% MOLP snack prototypes). The 1% MOLP snack prototype was acceptable for all sensory attributes as opposed to 3% and 5% MOLP snack prototypes, thus it was analyzed for nutritional composition. The results showed that the 1% MOLP snack prototype had more calcium, magnesium, potassium, phosphorus, zinc, manganese, iron, crude protein and less fat content in comparison to the control (0% MOLP). The nutritional analysis results were statistically significant ($p<0.05$) except for calcium, magnesium, manganese and iron. During focus group discussions caregivers said they were willing to incorporate *Moringa oleifera* leaf powder into snacks for their children after thorough nutrition education because 90% were not familiar with *Moringa oleifera* leaf powder.

Conclusion and Recommendations

Moringa oleifera leaf powder-based snacks (prototypes) have the potential to provide children especially those located in rural areas, with food and nutrition security thus reducing

susceptibility to under – nutrition. *Moringa oleifera* leaf powder-based snacks seem not to be known at all in South Africa, therefore should be researched and developed as snacks that could be nutritionally beneficial to children.

PREFACE

The work described in this dissertation was carried out in the School of Agricultural, Earth and Environmental Sciences at the University of KwaZulu-Natal from June 2015 to January 2017, under the supervision of Dr Annette Van Onselen; Dr Muthulisi Siwela and Prof Unathi Kolanisi.

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DECLARATION

I, Nozipho Zungu, declare that:

1. The research reported in this dissertation, except where otherwise indicated is my original work.
2. This dissertation, or any part of it, has not been submitted for any degree or examination at any other university.
3. Where other sources have been used, they have not been copied and have been acknowledged properly.
4. This dissertation does not contain text, graphics or tables copied and pasted from the internet, unless specifically acknowledged, and the source being detailed in the dissertation and in the relevant reference section.

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ACKNOWLEDGEMENTS

First and foremost, I would like to appreciate my Heavenly Father, my all in all, for His favour and guidance. This study would not have been possible without Him. I acknowledge the following people who provided assistance during this study:

- The School of Agricultural, Earth & Environmental Sciences and the National Research Fund: RISA for funding.
- My mentor Prof Unathi Kolanisi, thank you for being my destiny helper and for your patience, support and encouragement.
- My supervisor and co-supervisor Dr Annette Van Onselen and Dr Muthulisi Siwela, for your support and guidance throughout the study.
- The Department of Dietetics and Human Nutrition (UKZN, Pietermaritzburg) for granting permission to utilize foods laboratory during food product development.
- Debbie Davies (Animal and Poultry Science, UKZN) for assistance with freeze drying of *Moringa oleifera* leaf powder-based snack prototypes.
- CEDARA College of Agriculture for assistance with the nutritional analysis of the *Moringa oleifera* leaf powder-based snack prototypes.
- The Luwamba Centre for approval to conduct the study in Ntambanana.
- Ntambanana community members for participating in the study.
- Ruth Olusanya, Thulisiwe Myeni, Limpho Moleleki, Sithandiwe Khoza, Ghirmay Zeina and Bhekwayinkosi Mzimela for their assistance with data collection during the survey and sensory evaluation.
- Ghirmay Zeina for statistical analysis.
- A special thank you to Denver Naidoo, Dr Feyisayo Odunitan-Wayas, Nomfundo Shelembe and Siyabonga Mbanjwa for their academic support. My colleagues whom I interacted and shared life with, thank you for your encouragement.
- My family, particularly my mother Sibongile and my niece Palesa, thank you for your prayers, love, care and support.
- My church (The Redeemed Christian Church of God: Dunamis Faith Assembly) for spiritual support, indeed God is still the same yesterday, today and forever (Hebrews 13 verse 8).

DEDICATION

This dissertation is dedicated to:

My mother (Sibongile Mavis Zungu)

My greatest blessing, my confidant and pillar,

I pray God will keep you, so that you can eat the fruits of you labour.

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 Background and the research problem

There is an increasing trend in the consuming of processed snacks in low and middle income countries such as Asia, Latin America and Africa (Huffman *et al.,* 2014). Between 1999 and 2012, Ronquest - Ross *et al,* (2014) reported that there was a 53.3% increase in the consumption of sweet and savoury snacks in South Africa. In the top 25 foods that were mostly consumed by children (n =2868) in the 2005 National Food Consumption Survey of South Africa, salty snacks appeared as number 21 with an average daily intake of 30 g (Labadarios *et al*., 2005).

Snacking is an important consumption pattern that helps children to acquire daily nutrient needs for proper growth and development. Snacks can be classified into two categories of healthy and unhealthy. Healthy snacks that should be eaten by children must be obtained from different food sources such as fruits, vegetables, grains, protein and dairy (Serrano & Powell, 2013). The World Health Organization (2010) considers snacks to be unhealthy when they contain added sugar referred to as "sugary snack foods" which include sweets, biscuits, cookies and candy which increase energy levels but are not necessary rich in nutrients; are high in salt referred to as "savoury snack foods" which include chips, crisps, biscuits/crackers and contain trans fatty acids.

Caregivers usually purchase unhealthy snacks for their children because they are cheaper, have a longer shelf life, require no/less preparation and children are accustomed to eating them from a very young age thus rendering healthier snacks (e.g. vegetables; fruits; dairy, protein and grain products) unacceptable (Huffman *et al.,* 2014; Leyden, 2011). A study by Tshabalala (2014) conducted on children who were protein-energy deficient also reported a similar trend of caregivers purchasing unhealthy snacks over healthy snacks because of limited purchasing power and extended shelf life. The study further referred to this as indirect deprivation of children's right to food. The deprivation of food leads to food and nutrition insecurity and malnutrition. In 2014, sixteen million children, globally, were reported to be severely wasted. About 159 million children were stunted and 14% were underweight

(UNICEF *et al.,* 2015). The mortality rate of children was estimated to be 3.1 million, annually, and micronutrient deficiencies contributed to 1.1 million deaths, globally (Von Grebmer *et al.,* 2014).

Nearly 2.3 million children in South Africa were reported to be undernourished with 21-48%; 8-15% and 3.7% who were stunted; underweight and wasted, respectively (Gitau, 2009; Shisana *et al.,* 2013). Iron and vitamin A deficiencies are the most prevalent micronutrient deficiencies in the world, especially in children (Bailey *et al.,* 2015). The prevalence of anaemia was found to be highest in preschool children residing in Africa (67.6%) and Southeast Asia (65.5%) (De Benoist *et al.,* 2008). A national survey in South Africa determined that most children had mild anaemia (10.7%) and moderate anaemia (8.6%). Anaemia occurred mostly in children between the ages of 24-35 months (15.2%) (Shisana *et al*., 2013).

Globally, 190 million preschool children are affected by vitamin A deficiency, and the deficiency is severely prevalent in Sub-Saharan Africa (48%) and South Asia (44%). The prevalence of vitamin A deficiency in South Africa was found to be severe in children under five years of age but more severe in boys with a percentage of 49.3% than in girls (39%) (Shisana *et al*., 2013). One in four people (220 million) are affected by hunger in Sub-Saharan Africa (FAO, 2015b).

Four nationally representative surveys in South Africa showed that the proportion of food insecure households decreased from 52.3% to 25.9% from 1999 to 2008, while the percentage of households at risk of food insecurity ranged from 23.0% to 27.9% between 1999 and 2005. (Labadarios *et al.,* 2011; Labadarios, 2008). Nevertheless, recent data from the South African National Health and Nutrition Examination Survey (SANHANES-1) suggests no improvement (Shisana *et al.,* 2013).

1.2 Importance of the study

The Sustainable Development Goals (SDGs) attempt to build on the progress made by the previous Millennium Development Goals (MDG's). The SDGs comprise of 17 goals to be achieved by 2030. The third SDG aims to "ensure healthy lives and promote wellbeing for all at all ages" (WHO 2015). In line with the attempts of the SDGs, this study seeks to contribute to the third aim of the SDG'S by developing snacks fortified with *Moringa oleifera* leaf powder (MOLP).

In Sub-Saharan countries, the *Moringa oleifera* tree is underutilised as a food source whilst it is considered a "miracle tree" because of its nutritive value. According to Fuglie (2001) a 100 g of *Moringa oleifera* leaf powder contains 10 times more vitamin A than that of carrots, half the vitamin C of oranges, 17 times the calcium of milk, 15 times the potassium of bananas, 25 five times the iron of spinach and 9 times the protein of yoghurt. Utilizing *Moringa oleifera* leaf powder in food has the potential to decrease malnutrition, especially in children (Fahey, 2005) and can possibly contribute towards eradicating food and nutrition insecurity because of its agricultural characteristics of being drought resistant and in full leaf during the dry season (Price, 2007; Mishra *et al.,* 2012). Incorporating *Moringa oleifera* into snacks could also contribute to its awareness as a food source in South Africa rather than being limited to be a medicinal plant (Department of Agriculture, Forestry and Fisheries, 2013).

According to Kruger & Gericke (2002) there is a paucity of information about snacking habits of children, globally, and in South Africa. The knowledge generated from this study about snacks given to children by caregivers will contribute to information that is available.

1.3 Aim of the study

The overall aim of the study was to assess consumer acceptability of *Moringa oleifera* leaf powder-based snacks by caregivers as a nutritious snack for children to enhance food and nutrition security.

1.4 Research objectives

1.4.1 To identify snacks that were mostly given to children under 5 years of age in Ntambanana, KwaZulu-Natal.

1.4.2 To assess the quality (colour, texture, nutrient content) of *Moringa oleifera* leaf powder-based snack prototypes.

1.4.3 To determine caregiver's acceptability of *Moringa oleifera* leaf powder–based snack prototypes.

1.4.4 To determine caregiver's perceptions towards *Moringa oleifera* leaf powder.

1.5 Hypotheses

1.5.1 The snacks that were mostly given to children in Ntambanana unhealthy snacks.

1.5.2 The sensory attributes of *Moringa oleifera* leaf powder–based snacks were less acceptable because of unfamiliar sensory attributes of green colour (attribute of chlorophyll pigment in leaves), aroma (pungent herby smell) and taste (grassy).

1.6 Assumptions

1.6.1 Community members of Ntambanana knew about the utilization of *Moringa oleifera* leaf powder in food.

1.6.2 The survey participants answered all questions honestly and without bias.

1.6.3 The focus group discussion participants gave truthful replies about their perceptions.

1.6.4 The consumer panel for the sensory evaluation were free from sensory defects.

1.6.5 If caregivers accepted *Moringa oleifera* leaf powder–based snack prototypes, chances of the snacks being given to children for consumption would increase.

1.7 Definition of terms

Malnutrition

Malnutrition an abnormal physiological condition, typically due to eating the wrong amounts and/or kinds of foods; encompasses under-nutrition and over-nutrition (Von Grebmer *et al.,* 2014).

Under-nutrition

Under-nutrition: deficiencies in energy, protein, and/or micronutrients (Von Grebmer *et al.,* 2014).

Hidden hunger or micronutrient deficiency

Micronutrient deficiency (also known as hidden hunger): a form of under-nutrition that occurs when intake or absorption of vitamins and minerals is too low to sustain good health and development in children and normal physical and mental function in adults. Causes include poor diet, disease, or increased micronutrient needs not met during pregnancy and lactation (Von Grebmer *et al.,* 2014).

Consumer acceptability

The degree of liking or disliking of a food product based on the consumer's sensory perceptions in terms of the products appearance, taste, aroma and texture (White & Prescott, 2007).

Food and nutrition security

Food and nutrition security is a condition under which adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life (Pangaribowo *et al.,* 2013).

Nutritional Composition (quality)

Nutritional composition is the amount and type of nutrients such as proteins, fats, carbohydrates, water, vitamins and minerals in food products (Belitz *et al.,* 2009).

Perceptions

A person's frame of reference emerging from previous experiences, beliefs, likes, dislikes, opinions, feelings and other psychological factors of unknown origin (Barrios & Costeil, 2004).

Snacks

Snacks for young children are defined as foods eaten between meals – usually self-fed, convenient and easy to prepare (WHO, 2005).

Caregiver

Caregiver for this study can be defined as any person (whether male or female, parent or guardian, sibling or relative) in the household who is responsible for taking care of children, especially in purchasing, preparation and feeding of food.

1.8 Organization of the dissertation

The layout of the dissertation is as follows:

Chapter 1: Introduction and problem statement

Chapter 2: Literature review

Chapter 3: Research Methodology

Chapter 4: Results of the study

Chapter 5: Discussion of results

Chapter 6: Limitations, conclusion and recommendations

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Globally, South Africa is considered to be a food secure country at national level but at household level there is food insecurity (Bureau for Food and Agricultural Policy Baseline, 2013; Hendricks, 2014). A national survey by Shisana *et al,* (2013) reported that 28.3% of the South African population was at risk of hunger and 26.0% of the population experienced hunger, when adding both these percentages it becomes evident that more than half (54.3%) of South Africans are food insecure. The country is also faced with a double burden of over- and under nutrition coupled with poverty and agricultural challenges that further propel the vicious cycle of food and nutrition insecurity (Shisana *et al*., 2013). In this chapter, a literature review is presented with the aim of depicting the various interlinked causes of food and nutrition insecurity and malnutrition, their effects especially on children to propose a possible resolution.

2.2 The concept of food and nutrition security

The concept of food and nutrition security is an emerging term that combines two terms of food security and nutrition security. A state of food security is attained "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences" (Food and Agriculture Organisation, 1996). According to Klennert (2005) this definition already included aspects of nutrition but not sufficient, and he further defined nutrition security as an adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times. The 2012 State of Food Insecurity in the World Report defines nutrition security as "a situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, to ensure a healthy and active life for all household members". Thus, nutrition security can be said to differ from food security in that it considers the aspects of adequate caring practices, health and hygiene in addition to dietary adequacy" (FAO, 2012).

Weingärtner (2010) combined these two terms and defined food and nutrition security as a condition under which adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life. The South African policy on food and nutrition security defined food and nutrition security as "access to and control over the physical, social and economic means to ensure sufficient, safe and nutritious food at all times, for all South Africans, in order to meet their dietary requirements for a healthy life" (DSD & DAFF, 2013). Food and nutrition security has four fundamental interlinked pillars which are food availability, accessibility, utilization and stability.

2.2.1 Food availability

Availability of food usually implies that for households to be food secure, food must be available in adequate quantities and be of proper quality (Dube, 2013). Food should be made available at national level through transportation and distribution, storage and processing of food, food production and food trade (Burchi *et al.,* 2011). Transportation and distribution entails moving food from a location to another so that it can be distributed per demand to different areas or locations within a country. To avoid food shortages, spoilage and deterioration the surplus must be stored properly for example storage of maize in silos, to be made available when required. Processing of food entails prolonging the shelf life of perishable foods or creating a variety, for example fresh fruit and dried fruit. Food production and food trade requires a country to be able to produce enough food to feed its population and then to export surplus and food that has low production levels to be imported from other countries and made available in the markets. According to Dube (2013) for food security to be attained food availability is essential but not as the sole dimension.

2.2.2 Food accessibility

Food access signifies the availability of sufficient resources at household level to obtain appropriate food for a nutritious diet (Dube, 2013). A nutritious diet for all household members can be achieved through balanced intra-household distribution of food, diversified

sources of income and access to different markets. Households can have access to food through markets, transfers, gifts and grants. If food is obtained from markets, different sources of income are required. The food that is purchased in the household should be affordable, culturally acceptable, preferred and diverse in order to meet different dietary needs. Having access to food does not guarantee that every household member will consume a nutritious diet because of either the types or kinds of food/s that are purchased and on who is allowed (distribution) to consume the food. Therefore, accessibility of food within a household can be viewed from two angles, the first being the availability of the food and the ability to obtain access to food once it is available in the household (intra-household distribution of food) (Dube, 2013).

Other means that households can utilize in order to have access to food is by promoting sustainable farming practices, allowing access to land for agricultural production, campaigning for the growth of small scale farmers and implementing social protection procedures for the vulnerable household members, which are usually woman and children (Chitiga-Mabugu *et al.,* 2013).

2.2.3 Utilization of food

Food utilization can be viewed as the eventual consumption of food. Food utilization as a pillar can be viewed as a fundamental pillar that links the terms food security and nutrition security to give the concept of food and nutrition security. According to Gross *et al,* (2000) the inclusion of utilization as a food security pillar underlines that ***'Nutrition Security'*** is more than ***'Food Security'.*** The main aim of food utilization is that adequate nutritional adsorption, good nutritional outcomes and nutritional security are ensured. Food utilization involves factors that go beyond adequacy of the diet and quantity but brings in the importance of non-food inputs. These non-food inputs include safe water; sanitation; nutrition and health education and health care services (Burchi *et al.,* 2011).

The utilization of food within the household depends on the level of nutritional knowledge that food handlers or caregivers have concerning food handling and preparation. For example, a caregiver may lack procedural knowledge of properly thawing meat and decide to thaw it outside the refrigerator at room temperature, thus creating a breeding ground for micro-organisms that can cause food poisoning. In such situations, the household can be rendered food and nutrition insecure because of improper food handling.

The matter can further be propagated by a lack of knowledge on management of illnesses and inaccessibility to health care services. For household or individual food and nutrition security the utilization of food as a pillar should be advocated for through nutrition education; maternal and child care; water and sanitation (Boadi *et al.,* 2005).

2.2.4 Stability in food

Stability refers to food and nutrition security being maintained over time (Dube, 2013). Stability is an umbrella term that suggests that for individuals or households to be food and nutrition secure there should be consistency in the availability of food in terms of accumulation of stocks and diversification in food production systems, despite occurrences of natural and man-made disasters that require households to become resilient. Stability in access requires households to implement different livelihood strategies to sustain household safety nets, prevent loss of entitlements and to focus on achieving a diversified diet for the household. Stability in utilization suggests that people should have limitless access to health care where they receive education on nutrition and health related topics, proper sanitation practices and on using clean safe water. Thus, if all these pillars are in place and are functioning properly individuals or households of a country can be declared food and nutrition secure despite economic statuses or geographical location. According to Drimie *et al,* (2009) food availability, accessibility and utilization must be maintained over a long period of time given the political; socio-economic; natural and policy shocks and stresses. These food and nutrition security pillars can be measured at different levels of society using different indicators to determine whether there is food and nutrition security or insecurity as shown in Appendix A.

2.3 Food and nutrition security in Sub-Saharan Africa

Sub-Saharan Africa is among the two regions of the world after Southern Asia that have achieved slow progress in ensuring food security for its population. A yearly increase of 2.7% in the population size from 507 million people in 1990 to approximately 936 million in 2013, is not assisting in combating food and nutrition insecurity. An indicator for hunger that has been widely used to measure food and nutrition insecurity is the Prevalence of Undernutrition (PoU) (further discussed in section 2.4 of this literature review), the PoU in 2014-2016 was found to be highest in the region of sub-Saharan Africa with 23.2% of the population reported to be undernourished, meaning that one in four people (approx. 220 million people) were affected by hunger (FAO, 2015b).

A negative outcome in any of the indicators (Appendix A) used to measure food and nutrition security can declare a region, nation, and community or household's food insecure. The contributing factors to food and nutrition insecurity in sub-Saharan Africa are rooted in low average income, poverty, unmodernised farming that makes the region to depend on food imports, poor infrastructure (e.g. transport), and political instability (The Economist Intelligence Unit, 2014).

2.3.1 Food and nutrition security as a right to food in South Africa

In section 27(1)(b) of the constitution of South Africa it is stipulated that every South African has a right to food, which means the government has a responsibility of assuring that citizens basic food needs are meet by following all necessary procedures to ensure the right to food security (Republic of South Africa, 1996). In the 2012 National Planning Commission, section 28(1) it is further written that children have an unconditional right to basic nutrition.

The levels of food insecurity at household level were reported to be high by Hendricks (2013) and having no legislative measures in place is not helping to solve the problem, because the food and nutrition insecurity situation in South Africa is further perpetuated by developmental hindrances such as poverty, increasing fuel and food prices, high levels of

unemployment, stagnant economic growth and high inequality, changing household structures and challenges with land ownership, education, health, water and sanitation (Stats SA, 2014). The Department of Planning, Monitoring and Evaluation (2014) report, showed that South Africa faces serious food security challenges in comparison to other countries such as Algeria, Brazil, Angola and Malaysia which have the same income levels.

The results as shown in Table 2.1 from four national surveys showed that the proportion of food insecurity in South African households halved from 1999 to 2008, decreasing from 52.3% to 25.9%, while the percentage of households at risk of food insecurity ranged from 23.0% and 27.9% between 1999 and 2005 (Labadarios *et al.,* 2011; Labadarios, 2008). Nevertheless, recent data from SANHANES-1 suggests no improvement since 2008 (Shisana *et al.,* 2013).

Table 2.1: Trends in food security status in South Africa: 1999-2012 (Shisana *et al.*, 2013)

Variable	**NFCS 1999 (n=2735)**	**NFCS-FB-I 2005 (n=2413)**	**SASAS 2008 (n= 1150)**	**SANHANES-1 2012 (n= 6306)**
Food secure	25%	19.8%	48%	45.6%
At risk of hunger	23%	27.9%	25%	28.3%
Experiencing hunger	52.3%	52%	25.9%	26.0%

NFCS – National Food Consumption Survey; NFCS-FB-I – National Food Consumption Survey-Fortification Baseline; SASAS – South African Social Attitudes Survey; SANHANES-1 – South African National Health and Nutrition Examination Survey

In 2013, a national policy on food and nutrition security was created and it was approved in 2014. The goal of the policy was to ensure availability, accessibility and affordability of safe and nutritious food at national and household levels through improved nutritional safety nets, nutrition education, alignment of investment in agriculture, market participation of emerging farmers and risk management (DSD & DAFF, 2013).

Numerous programmes have been implemented by government to try and address problems of food and nutrition insecurity for South African households such as the Integrated Nutrition Programme (INP), the National School Nutrition Programme (NSNP), the Integrated Food Security Strategy (IFSS), the Integrated Sustainable Rural Development Programme (ISRDP), the New growth plan (GoSA, 2009), the National Development Plan Vision 2030 and the Zero hunger strategy (Chitiga-Mabugu *et al.,* 2013).

2.3.2 Food and nutrition security in Kwazulu-Natal

The population of KwaZulu-Natal (KZN) has been estimated to be 54. 96 million people (Stats SA, 2015). Dietary diversity especially for children has improved in KZN due to agricultural support, school feeding programmes and social grants but households still face challenges of food insecurity and hunger. As indicated in Table 2.2, households (37.3%) in KZN are reported to be food secure, but the SANHANES-1 (2012) data showed, that 28.3% of households were at risk of experiencing hunger and 34.4% of households experienced hunger (Shisana *et al.,* 2013). When these percentages are added, it is evident that more than half (62.7%) of KwaZulu-Natal households are still faced with food insecurity.

Table 2.2: Recent food (in) security indicators in South Africa (Stats SA, 2014; Shisana *et al.,* 2013)

	Province of South Africa									**South Africa**
Stats SA GHS 2013 data	**Eastern Cape**	**Free States**	**Gauteng Province**	**KwaZulu-Natal**	**Limpopo**	**Mpumalanga**	**Northern Cape**	**North West**	**Western Cape**	**Republic of South Africa**
Food access severely inadequate	7.0%	5.4%	4.7%	4.0%	1.7%	8.8%	9.6%	14.7%	8.3%	6.1%
Food access inadequate	22.4%	21.1%	13.0%	20.9%	7.0%	20.7%	21.0%	22.6%	15.0%	17.0%
Food access adequate	70.6%	73.5%	82.3%	75.2%	91.3%	70.6%	69.3%	62.7%	76.8%	76.9%

Stats SA GHS – Statistics South Africa General Household Survey

Table 2.2: Recent food (in) security indicators in South Africa continued (Stats SA, 2014; Shisana *et al.,* 2013)

SANHANES-1 2012 data	**Eastern Cape**	**Free States**	**Gauteng Province**	**KwaZulu-Natal**	**Limpopo**	**Mpumalanga**	**Northern Cape**	**North West**	**Western Cape**	**Republic of South Africa**
Prevalence of the experience of hunger	36.2%	28.8%	19.2%	28.3%	30.8%	29.5%	20.7%	29.5%	16.4%	26.0%
Household experience of hunger	32.4%	31.9%	24.8%	34.4%	27.3%	15.5%	22.8%	30.0%	25.6%	28.3%
Food secure	31.4%	39.3%	56.0%	37.3%	41.9%	55.0%	56.5%	40.4%	57.9%	45.6%

Shisana *et al.,* 2013: SANHANES-1 – South African National Health and Nutrition Examination Survey

2.4 Causes of malnutrition in children

Malnutrition is an abnormal physiological condition, typically due to eating the wrong amounts and/ or kinds of foods. The term malnutrition is an intermediate term consisting of both under- and over- nutrition. Undernutrition is caused by consuming too few essential nutrients or using or excreting them more rapidly than they can be replaced or undernutrition can also be defined as deficiencies in energy, protein and/or micronutrients. Over nutrition results from eating too much, eating too many of the wrong foods, not exercising enough, or taking too many vitamins or other dietary replacements (Von Grebmer *et al.,* 2014). For this study, focus will be on undernutrition and henceforth, the word malnutrition will be referring to undernutrition and these terms will be used inter-changeably.

There are basic, underlying and immediate causes of malnutrition identified by UNICEF as shown in Figure 2.1. The causes of malnutrition are interlinked and operate at national, community and individual levels, a positive or negative outcome in any level will have an effect in other levels. (UNICEF, 2013).

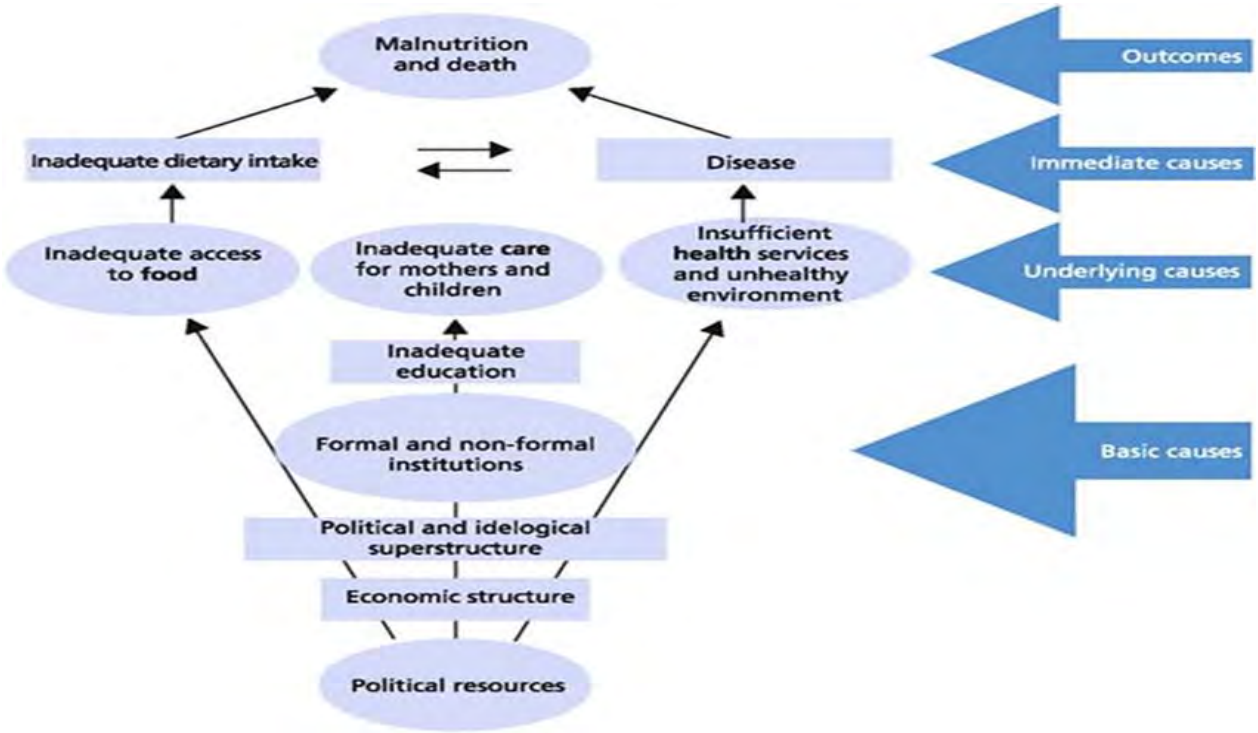

Figure 2.1: The UNICEF conceptual framework of malnutrition (UNICEF, 2013)

Undernutrition can be classified into protein energy malnutrition (PEM) and micronutrient deficiencies also known as hidden hunger. Protein energy malnutrition and micronutrient deficiencies will further be discussed, including prevalence's at global and national levels and their effects on children.

2.4.1 Protein energy malnutrition

The term protein energy malnutrition has traditionally been used to describe the condition that develops when the diet delivers too little protein, too little energy, or both. Protein energy malnutrition becomes evident in children through, syndromes such as kwashiorkor; marasmus; or a combination of both.

2.4.1.1 Kwashiorkor

Kwashiorkor is a Ghanaian word that indicates sickness that occurs to a first-born child, when a second child is born. The sickness occurs because of being weaned early from breastmilk, which is nutrient-dense and protein-rich to a starchy, protein-poor cereal to allow the new-born to breastfeed. The first child reacts to weaning in a negative manner by becoming irritable or withdrawn, which leads to a loss of appetite and to illness. That is why kwashiorkor is a form of acute malnutrition because it results from recent severe food deprivation. Failure to grow and develop; anaemia; fatty liver; oedema; apathy; changes in the pigmentation of hair and skin are all signs indicative of kwashiorkor in children (Whitney & Rolfes, 2013).

2.4.1.2 Marasmus

Marasmus is a chronic form of malnutrition that occurs because of severe deprivation to food. Marasmus comes from the Greek word, meaning "dying away". Children living in poverty stricken areas are at a greater risk of suffering from marasmus because they do not obtain adequate nutrients from food but live off on diluted cereal drinks. Wasting (loss of body fat and muscle); underweight; apathy and poor growth are symptoms of marasmus (Whitney & Rolfes, 2013).

Indicators that are used to measure protein-energy malnutrition in children are, wasting, stunting and underweight. Wasting is a condition that is usually associated with starvation and/or disease that leads to substantial weight loss. A child is wasted when he/she is too thin for his/her height (low weight-for-height). Children who are too short for their age, are considered to be stunted (low height-for-age). Retardation in height is not physically restrictive but affects intellectual or cognitive abilities. If a child gains little weight as he or she grows in relation to their age, they are considered to be underweight (World Food Programme, 2013).

Table 2.3 shows the recommended reference intakes of macronutrients for children from 1-8 years and requirements are similar for both males and females, if children do not obtain these nutrients as recommended daily, they become deficient in macronutrients thus contributing to protein energy malnutrition.

Table 2.3: Macronutrient requirements for children aged 1-8 years old (Food and Nutrition Board, 2000)

Nutrients	**Examples of food sources**	**Functions**	**Male 1-3 RDA*/AI** (g/day)**	**Male 4-8 RDA/AI* (g/day)**	**Female 1-3 RDA/AI* (g/day)**	**Female 4-8 RDA/AI* (g/day)**
Carbohydrates	Starches, for example, pasta, potatoes. Sugars, for example, those found in fruits, soft drinks and sweets.	Provides the body with energy and aids in maintaining adequate body weight.	130	130	130	130
Total fibre	Grains such as brown rice, bran and oats.	Aids in maintaining a healthy digestive system.	19	25	19	25
Protein	Sources of protein are both from animal and plant products, for example, meat, fish, poultry, legumes and nuts.	Aids in the function, development and maintenance of cells and enzymes.	13	19	13	19

*RDA- Recommended Dietary Allowances **AI- Adequate Intake

2.4.1.3 The prevalence of protein energy malnutrition: Global perspective

From a global perspective, 16 million children were reported to be severely wasted, out of 50 million that were wasted. This translates to approximately a third of 2.4% that were severely wasted in 1 out of every 13 that were wasted. There has been a reduction of 96 million in stunting of children in the world, even though 159 million children out of 667 million were still considered stunted. Underweight was prevalent in 14% of children in 2014 (UNICEF *et al.,* 2015).

The prevalence of stunting in children under 5 years of age, from 1990-2014 has been found to be unsatisfactorily decreasing in Oceania and Africa with percentages of 38.1% and 32.0, respectively. Asia has managed to decrease stunting by up to 47% but there is uneven progress within its sub-regions, with Eastern Asia doubling the decrease to 82% in comparison to Southern Asia's decrease of 41%. In all the world, 57% of stunted children reside in Asia and the other 37% was found in Africa. In Africa, there was a 23% increase in stunting with 47 million under 5-year-olds affected in 1990 to 58 million in 2014 (FAO, 2015a).

The acceptable range of wasting in children under five years is < 5%, only five regions namely Central America, South America, Eastern Asia, Caribbean and Central Asia were below this range, in the past two years. All sub-regions of Africa in 2014 had a poor range of 5 to < 10 % of wasted children. Southern Asia had a 14.2% range of wasted children in 2014, meaning children of Southern Asia are seriously wasted (range of between 10 to < 15%). In 2014: Western Africa, South- Eastern Asia and Oceania were almost approaching the public health emergency line with ranges of 9.0%, 9.3% and 9.0%, respectively. A majority of 68% (34.3 million) of wasted children live in Asia and 28% (13.9 million) reside in Africa (FAO, 2015a).

Even though underweight affected 14% of children, globally in 2014, the irony was that 16% (95 million) of children residing in developing countries were found to be underweight in the same year, meaning that the prevalence of underweight was higher by 2% when compared to the global prevalence. Chronologically, children under 5 years of age in four sub-regions of

Africa, namely Western Africa (20%), Eastern Africa (18%), Middle Africa (15%) and Southern Africa (11%) were affected by underweight in 2014. When all these percentages were added together they gave a total sum of 64%, meaning Africa had a higher percentage of underweight children when compared to other regions such as Asia (28%), Oceania (18%) and South-Eastern Asia (16%) which gave a total sum of 62% (FAO, 2015a).

2.4.1.4 The prevalence of protein energy malnutrition in South Africa

According to Shisana *et al,* (2013) undernutrition is responsible for 45% of deaths in South African children younger than 5 years, amounting to more than 3 million deaths each year. The nutritional status of children has been recorded in four nationally, representative surveys. As shown in Table 2.4, there has been a slight decrease of 7.5% (1994-2013) in children suffering from moderate stunting in South Africa. The prevalence of wasting in South African children has been fluctuating, it increased in 1999 to 10.3% and drastically decrease to 2.9% in 2013. Moderate and severe underweight has been gradually increasing, at averages of 4.2% and 0.8%, respectively.

Table 2.4: Prevalence of child malnutrition in South African children over the past 23 years (SAVACG, 1996; Labadarios *et al.,* 2005; Labadarios *et al.,* 2008*;* Shisana *et al.,* 2013)

Anthropometric Parameter	***SAVACG (1994)**	****NFCS (1999)**	*****NFCS: FB-I (2008)**	******SANHANES-1 (2013)**
Height-for-age (stunting)				
< 2 SDs	22.9%	21.6%	18.0%	15.4%
< 3 SDs	6.6%	6.5%	5.1%	3.8%
Weight-for-age (wasting)				
< 2 SDs	9.3%	10.3%	9.3%	2.9%
< 3 SDs	1.4%	1.4%	1.0%	0.8%
Weight-for-height (underweight)				
< 2 SDs	2.6%	3.7%	4.5%	5.8%
< 3 SDs	0.4%	0.8%	1.0%	1.1%

*Results for children aged 6-71 months
**Results for children aged 1-8 years
***Results for children aged 1-9 years
****Results for children aged 1-14 years

Stunting mainly affected boys (26.9%) and girls (25.9%) aged 0-3 years. Stunting (20.6%), wasting (6.8%) and underweight (12%) was found to be highest in children residing in rural areas (Shisana *et al.,* 2013).

2.4.2 Micronutrient deficiencies or hidden hunger

Micronutrient deficiencies (also known as hidden hunger) are a form of undernutrition that occurs when intake or absorption of vitamins and minerals is too low to sustain good health and development in children and normal physical and mental function in adults (Von Grebmer *et al.,* 2014). The reason why micronutrient deficiencies are known as hidden hunger is because in less severe cases of deficiencies, sufferers appear normal or nourished with signs of deficiencies not being too apparent or visible, hint: the term hidden hunger. From now on the terms micronutrient deficiencies and hidden hunger will be used interchangeably. There are various causes of hidden hunger which are related to the immediate causes of malnutrition and these include a poor diet that is mainly dependent on staple food crops (maize, wheat and rice); diseases, infections or parasites; and increased requirements of micronutrients during certain life stages such as pregnancy and lactation (Whitney & Rolfes, 2013; Von Grebmer *et al.,* 2014).

Micronutrients are required by the body in small quantities but they still play crucial roles in keeping the body healthy, and are classified into vitamins and minerals (University of Illinois, 2008). Vitamins are classified according to how they are stored in the body into fat soluble vitamins; these are the kind that is retained in the body for long periods of time and water soluble vitamins are stored for shorter periods of time. Minerals are categorized into major minerals and trace minerals; the word major signifies that they are needed in larger quantities than trace minerals which are required in smaller quantities (Lean, 2006; Gibney *et al.,* 2007; McGuire & Beerman, 2013). Dietary reference intakes of micronutrients especially for minerals is shown in Table 2.5 for children aged 1-8 years and nutritional requirements increase with age, a lack in obtaining the recommended dietary allowances renders children to be deficient or suffering from hidden hunger.

Table 2.5: Micronutrient requirements for children aged 1-8 years old (Food and Nutrition Board, 2000)

Nutrients	**Examples of food sources**	**Functions**	**Children 1-3 RDA/AI* (mg/day)**	**Children 4-8 RDA/AI* (mg/day)**
Potassium	Avocado, banana, potato, whole grains, asparagus, tomato, spinach, oranges, rock melon, dairy products, red meat	Keeps body fluid levels in balance, muscle and nerve function, glucose storage	3000	3800
Calcium	Milk and milk products, small fish with bones, tofu, broccoli, chard and legumes.	The principal mineral of bones and teeth, also involved in normal muscle contraction (including heart muscle).	700	1000
Phosphorus	Abundant in all animal foods.	A principal mineral of the bones and teeth; part of every cell; maintains acid-base balance.	460	500
Magnesium	Nuts, legumes, whole grains, beans, green leafy vegetables, seafood, chocolate.	Involved in bone mineralization, the building of protein, enzyme action, normal muscular contraction, and transmission of nerve impulses	80	130

*RDA- Recommended Dietary Allowances **AI- Adequate Intake

Table 2.5: Micronutrient requirements for children aged 1-8 years old cont. (Food and Nutrition Board, 2000)

Nutrients	**Examples of food sources**	**Functions**	**Children 1-3 RDA/AI* (mg/day)**	**Children 4-8 RDA/AI* (mg/day)**
Iron	Red meat, egg yolk, fish, chicken, legumes, spinach, dried fruit, tofu	Transports oxygen in the blood, optimal growth and cognitive function	7	10
Zinc	Dairy products, red meat, eggs, poultry, shellfish, nuts, soy beans	Immune function, enzyme and hormone production, healthy skin and eyes	3	5
Manganese	Nuts, whole gains, leafy vegetables, tea	Cofactor for several enzymes, bone formation	1.2	1.5

*RDA- Recommended Dietary Allowances **AI- Adequate Intake

2.4.2.1 The prevalence of micronutrient deficiencies

Approximately two billion people in the world, which is one in every three people are affected by hidden hunger (Von Grebmer *et al.,* 2014; Bouis *et al.,* 2009). The mortality rate of children is estimated to be 3.1 million, annually and micronutrient deficiencies contribute to 1.1 million deaths of children, globally. Hidden hunger is mostly present in Africa, South Asia and South of the Sahara (Weisstaub & Araya, 2008; Black *et a*l., 2013; Black *et al*., 2008).

The content of micronutrients in the human body is identified using biomarkers, which help to detect when there is an excess or deficiency (Von Grebmer *et al.,* 2014). Biomarkers for iron and vitamin A as the most prevalent micronutrient deficiencies globally and in South Africa are going to be briefly discussed.

- **Iron**

Iron can be classified into two types: namely haeme iron which is derived from animal food sources and non-haeme iron which is present in plants and is usually used for food fortification. Both types of iron are not easily absorbed by the body with an estimated bioavailability of < 5% for non-haeme iron and 12-25% for haeme iron. Even though iron is not easily absorbed into the body, the advantage is that whatever content that the body absorbs, can be preserved in the body for longer periods of time (Food and Nutrition Board, 2001; Bailey *et al.,* 2015).

The biomarkers that are used to measure iron content include plasma ferritin, transferrin saturation and hemoglobin concentrations. Ferritin is an iron storage protein, which helps to indicate the decrease of iron stores in the plasma. A value of < 10 µg/L indicates deficiency when plasma ferritin is used as biomarker for the first stages of iron deficiency in children aged from 0.5 – 15 years. Transferrin is an iron transport protein, and the percentage of transferrin that is saturated with iron is an indirect measure of iron deficiency which is derived from serum iron and total iron-binding capacity. For children aged from 0.5 – 4 and 5 – 10 years, transferrin saturation deficiency is indicated by percentages of < 12 and < 14, respectively. Haemoglobin (Hb) is the oxygen-carrying protein of the red blood cells that

transports oxygen from the lungs to tissues throughout the body. A low hemoglobin concentration of < 11 g/dl in children aged from 0.5 – 10 years indicates depleted iron stores and is usually used to determine anaemia (Whitney & Rolfes, 2013). Iron deficiency is among the most prevalent micronutrient deficiencies in the world, especially in children. Approximately 1.62 billion (25%) of the world's population has anaemia. Globally, the prevalence of anaemia was found highest in preschool children (47.4%) and in Africa, a majority of 67.6% of preschool children were found to be anaemic. Following in the trails of Africa was Southeast Asia with 65.5% of preschool children having anaemia (De Benoist *et al.,* 2008).

The World Health Organization's (WHO) haemoglobin (Hb) cut of points for children under five years of age, are used to categorize the prevalence of anaemia into mild anaemia (Hb 10.9-10.0 g/dL); moderate anaemia (Hb 9.9-7.0 g/dL) and severe anaemia (<7 g/dL) (WHO, 2011). Using these cut-off points, a national survey in South Africa determined that a majority of children had mild anaemia (10.7%) and moderate anaemia (8.6%). Anaemia occurred most in children between the ages of 24-35 months (15.2%) (Shisana *et al.,* 2013).

- **Vitamin A**

Retinol, retinal and retinoic acid are the three vitamin A forms that are active in the human body. Retinol is derived from animal food sources and is responsible for reproduction, whereas retinal and retinoic acid are preformed from pro-vitamin A in plant food sources and they function to promote clear vision and proper growth. Vitamin A deficiency becomes a public health problem when the following WHO prevalence cut-offs are found for low serum retinol: mild (2-9%); moderate (10-19%) and severe (20% or more). Biochemically, vitamin A deficiency is indicated by retinol concentrations of < 0.70 µmol/l (used for children and adults), as well as eye examination for clinical purposes (Whitney & Rolfes, 2013).

Vitamin A deficiency was found to be severely prevalent in sub-Saharan Africa and south Asia with percentages of 48 and 44, respectively. In comparison to Southeast Asia and Oceania which reduced the prevalence of vitamin A deficiency from a severe 42% in 1991 to a mild 6%

in 2013; followed by Latin America and the Caribbean with a reduction from a severe 21% to a moderate 11% (Stevens *et al.,* 2015). South Africa as a country belonging to the Sub-Saharan region is no exception because it has a severe prevalence of 43.6% in vitamin A deficiency. Globally, 190 million preschool children are affected by vitamin A deficiency with 250-500 million children suffering from blindness and half of these children faced with a possibility of death due to blindness (WHO, 2009).

The prevalence of vitamin A deficiency in South Africa was found to be severe in children under five years of age but more severe in boys with a percentage of 49.3% than in girls (39%). A low mean retinol concentration of 0.74 µmol/l was found in black South African children, consequently increasing the prevalence of vitamin A deficiency to 45.4% when compared to coloured children who had lower vitamin A deficiency (33.4%) and a higher mean retinol concentration of 0.81 µmol/l (Shisana *et al.,* 2013).

2.5 Factors affecting children's food choice

There are several factors that contribute to food choices made by or for children and these factors are mainly rooted in the availability and accessibility of the type of food consumed. A brief discussion about these factors is going to follow but the focus will be on snacking as a dietary food choice for children.

2.5.1 Parental and peer influence

Parents play an important role in dietary habits of children because food choices for children formed by parents at a young age, will ultimately determine food choices that children will make as they grow up. A study by Brown & Ogden (2004) found that snacking habits of parents and children were related, parents who snacked on unhealthy snacks such as chips, chocolates and biscuits made their children to opt for similar snacks, in comparison to children that mirrored healthier snack choices, which were similar to their parents.

A challenge for parents that could contribute to giving children convenience or unhealthy or processed foods could be the lack of time available to prepare proper or healthier meals for the family. Such situations occur regularly that a habit is formed which creates a lasting impression on children and influences their future dietary food choices (FAO, 2005; Boots *et al.,* 2015). Research by Eisenberg *et al,* (2012) on the relationship between parenting behaviours and dietary fat consumption of young children showed that parents who were more controlling in what their children consumed, resulted to a more frequent fat consumption by children (p<.01). However, parents that demonstrated healthier eating practices resulted in their children consuming less fat (p<.01).

Nutritional knowledge of parents is also a contributing factor that helps to shape dietary habits for children. A study by Yabancı *et al,* (2014) found that children of mothers who had higher nutritional knowledge levels, were of normal weight compared to those with lower nutritional levels. This implies that the nutritional status of children and eating patterns are directly proportional to nutritional knowledge of parents or caregivers.

Normally when children are around other children, their food consumption can either increase or decrease or there can be a change in food choices. Research conducted by Salvy (2012) reported that peers and friends can influence one another's eating patterns. Peers influenced snack and soft drink consumption of children aged from 12-17 years and this was also connected to the accessibility of these items at schools (vending machines/tuck shops) (Wouters *et al.,* 2010).

2.5.2 Food available at schools

A study in Scotland found that there were many food outlets surrounding secondary schools in New Glasgow, thus making fast foods easily available to learners (Ellaway *et al.,* 2012). While a study conducted in Canada concluded that there was a necessity for approaches aimed at changing the food environment surrounding schools so that the nutritional status of

children could be improved depending on the quality of foods sold by surrounding food retailers (Héroux *et al.,* 2012).

A study in South Africa reported similar results, where 11 primary schools in Pietermaritzburg, KwaZulu-Natal had tuck shops that frequently sold unhealthy foods to children compared to healthier options (Wiles *et al.,* 2011). Faber *et al,* (2014) found that children often opted for unhealthy food items because they were cheaper and larger in quantity then healthier foods that were available for purchase.

The South African National School Nutrition Programme (NSNP) started providing meals to underprivileged schools in 1994 but the energy and carbohydrate requirements of children aged 7-10 and 11-18 years was found not to be adequately met by the programme in the Free State Province and only 10% of the meals provided were able to meet the nutrient requirements for calcium and zinc. Proper meal planning for the program is required so that children can be able to acquire their nutritional needs across all age categories and food preference must also be taken into consideration (Nhlapo *et al.,* 2015; Department of Education, 2014).

2.5.3 Food selectivity (Neophobia)

Neophobia is a protective mode that prevents animals and humans from consuming something that could be harmful to them. This then makes people to constantly choose foods that they are familiar with because they regard those foods as safe. New food experiences are usually avoided and the diet ends up lacking in variety due to food neophobia, which is also commonly known as the fear of consuming new or unfamiliar foods (Laureati *et al.,* 2014).

Children generally reject eating vegetables that are nutrient rich; this could be explained by a possible imprinting of sweet and glutamate flavours because of breast milk containing both free glutamate and free sugars (Breslin, 2013). According to Laureati *et al,* (2014) neophobia is more likely to be reduced in children 9 years or younger as the child is still in the process of

developing food preferences. Therefore, interventions directed towards introducing children to healthy foods should be done during the early stages of childhood.

Russell *et al,* (2015) conducted a study on strategies employed by parents to influence their children's food intake. The research findings revealed that parents adopted various strategies (some effective and some ineffective); however, parents whose children displayed high food neophobic tendencies (where a dislike of new foods was apparent), used fewer effective strategies to increase diversity in the child's diet.

Parents play a key role in determining their child's attitude towards food. Behaviours used by parents can either be constructive, for example, encouraging the child to eat by explaining the benefits of the food item or allowing the child to help in the meal preparation. Destructive behaviour is whereby parents follow unhealthy diets and the child mirrors those eating patterns thus limiting food choices/variety and this can result to a neophobic child. Neophobia may reduce the efficiency of programs that are intended to increase food diversity or promote healthy food choices (Russell *et al.,* 2015).

2.5.4 Snacking

The World Health Organisation (2005), defined snacks for young children as foods eaten between meals which are usually self – fed, convenient and easy to prepare. Giving children healthy snacks provides them with good nutrition, supports lifelong healthy eating habits, and helps to prevent costly and potentially-disabling diseases, such as heart disease, cancer, diabetes, high blood pressure, and malnutrition (Serrano & Powell, 2013). Snacks consumed by children should come from different food groups. Parents or caregivers can plan healthier snacks for their children following the example illustrated in Table 2.6.

Table 2.6: Healthy snacks and serving portions for children (Serrano & Powell, 2013)

Food group	**1 – 3 year olds**	**3 – 4 year olds**	**5 year olds**	**A serving of the following examples of snack foods is equal to:**
Fruits - Provide vitamins and minerals, essential for good health	2 to 4 servings per day	4 or more servings per day	5 servings per day	-One medium sized fresh fruit for example apple, orange, banana, and pear. -Small glass of unsweetened pure fruit juice – dilute with plenty of water. -Small bowl of tinned fruit in natural juice, small bowl of chopped fruit, fresh fruit salad -three dessertspoons of stewed fruit
Vegetables - Provide vitamins and minerals, essential for good health	2 to 4 servings per day	4 or more servings per day	5 servings per day	-Two tablespoons of vegetables or 3 dessertspoons of salad -Bowl of home-made vegetable soup

Table 2.6: Healthy snacks and serving portions for children cont. (Serrano & Powell, 2013)

Food group	**1 – 3 year olds**	**3 – 5 year olds**	**A serving of the following examples of snack foods is equal to:**
Grains - Provide energy to help work and play	4 servings per day	4 to 6+ servings per day	-One slice of bread or a small bread roll -One small bowl of cereal (e.g. 30g variety size pack) -Two cream crackers -One medium potato -Three dessertspoons of boiled rice or pasta
Protein foods – Needed for growth and development	2 small servings per day	2 servings per day	-Small pork or lamb chop -Two slices roast or boiled meat -2 slices of chicken or turkey -Medium fillet of fish -Two eggs -Six tablespoons of baked beans, peas, lentils
Dairy - Provide calcium for healthy bones and teeth	3 servings per day	3 servings per day	-One glass of full fat milk. 1 glass of yoghurt -Matchbox sized piece of cheese

In ideal situations, caregivers would follow the example illustrated in Table 2.6 to form snacking patterns for their children thus contributing to proper dietary intake and food choices

2.5.4.1 Snack consumption of children internationally and in South Africa

There is a paucity of information about snacking habits of children especially from 1-5 years, globally and in South Africa (Kruger & Gericke, 2002). According to Huffman *et al,* (2014) information that is available, has shown that the consumption of processed snacks is on the rise in low – and middle – income countries such as Asia, Latin America and Africa. According to the World Health Organisation (2010) snacks can be considered unhealthy when they contain added sugar (referred to as 'sugary snack foods' including sweet biscuits, cookies and candy); are high in salt (referred to as 'savoury snack foods' including chips, crisps or biscuits/crackers) are low in nutrient content and contain trans fats.

The consumption of sugary snacks was found to be highest in Asia and Africa where ranges from 36-68% and 18-40% were found, respectively. In comparison to Zambia and Zimbabwe which had the lowest range of 11-13% for children between 6-23 months consuming sugary snacks. A study involving 352 households in Mangochi district (Malawi) in 2011, reported that 53% of households purchased store bought snack foods (buns/scones, biscuits, chocolate, potato chips, sweets and candies) for their 9 months and 15 months old children. Sixty percent of 537 households who had 9 months old children and 329 households with children aged at 15 months, in Burkina Faso spent one US dollar (R12. 89) daily purchasing snacks such as cookies, cakes, candy/cholate and soda for their children (Huffman *et al.,* 2014).

In the top 25 foods that were mostly consumed by children (n = 2868) in the 2005 National Food Consumption Survey of South Africa, salty snacks appeared as number 21 with an average daily intake of 30 g (Labadarios *et al.,* 2005). Between 1999 and 2012, it was reported by Ronquest – Ross *et al,* (2014) that there has been a 53.3% increase in the consumption of sweet and savoury snacks in South Africa.

2.6 Food fortification as a solution to improving the nutritional status of children

Fortification can be defined as a means of increasing the content of essential micronutrients in basic foods; i.e., vitamins and minerals (including trace elements), to improve the nutritional quality of the food supply (Method & Tulchinsky, 2015). Food fortification is one of the strategies that has been used safely and effectively to prevent micronutrient deficiencies and has been practiced in developed countries for well over a century now. For example, in the United States of America, fortification of salt with iodine; milk with vitamin D; flour with iron, bread with niacin and other B vitamins began as early as 1920 and 1938 for bread. While in Denmark margarine began to be fortified with vitamin D in the 1950's and in 1954 fortification of hydrogenated vegetable oil with vitamin A and D began in India (WHO & FAO, 2000). To help prevent neural tube birth defects, the fortification of flour with folic acid has been declared compulsory for over 60 countries (Oakley & Tulchinsky, 2010).

2.6.1 Types of food fortification

There are three types of food fortification, namely there is mass fortification, targeted fortification and market driven fortification. Food vehicles commonly used for fortification can be grouped into three broad categories: staples (wheat, rice, oils), condiments (salt, soy sauce, sugar), and processed commercial foods (noodles, infant complementary foods, dairy products) (Das *et al.,* 2013).

Mass fortification involves the addition of one or more micronutrients to foods commonly consumed by the public, such as cereals, condiments and milk. Mass fortification is rendered mandatory by government bodies when there is an indication that a majority of the population is at risk of experiencing certain micronutrient deficiencies. Indications or symptoms of deficiencies that call for mandatory fortification are sometimes easily noticeable or clearly visible through anthropometric measurements, at other times biochemical measurements should be taken so that deficiencies can be detected. Sometimes mass fortification is implemented as a preventative or protective measure for the benefit of the population (Piramal Healthcare Limited, 2010; Fiedler *et al.,* 2014).

Fortification of food for specific subgroups of the population, to increase the intake for that particular group rather than that of the population, as a whole is known as targeted fortification. Targeted fortification can be implemented through complementary foods for infants and young children, for example biscuits for children and pregnant women; blended foods for emergency feeding of displaced persons and through foods developed for school feeding programmes (Piramal Healthcare Limited, 2010).

Market-driven fortification entails the addition of one or more micronutrients to processed food products for mutual benefit of the food manufacturer and the consumer. As much as the decision of whether to fortify a processed food product or not lies with the manufacturer, they still must follow regulatory limits set by the government. The advantage of market-driven fortification is that it can make available micronutrients (e.g. iron, calcium, vitamin C and vitamin B2) that are not easy to incorporate through mass fortification of staple foods, due to cost and safety limitations. The disadvantages involve a change in diet especially if the fortified foods are attractive to consumers but not actually healthy; overconsumption of micronutrients due to a similar serving size of the fortified food (e.g. breakfast cereals, beverages, nutrition bars) that is meant for consumption by all household members (Piramal Healthcare Limited, 2010).

2.7 *Moringa oleifera* as a home food fortificant

Moringa oleifera is known by many names in different places such Mronge (Kenya); *Moringa oleifera* (Spanish); Sahjan (Asia); Haleko (Ethiopia) and drumstick tree, (Horse)radish tree, Mother's best friend, West Indian ben in English but it is commonly called the "Miracle tree" because of its nutritive value. Every part of the tree is edible but the leaves, flowers and pods are mostly preferred for consumption (Jideani *et al.,* 2014; Mbikay, 2012). Church World Service (CWS), Educational Concerns for Hunger and the Trees for Life Organization are the three non-governmental organizations that have been promoting the nutritional benefits of *Moringa oleifera* (Fahey, 2005).

There are approximately 14 species of *Moringa oleifera* trees from the *Moringa oleiferaceae* family which are *M. oleifera, M. arborea, M. borziana, M.concanensis, M. drouhardii, M. hildebrandtii, M. longituba, M. ovalifolia, M. peregrine, M. pygmaea, M. rivae, M. ruspoliana and M. stenopetala* (Paliwal *et al.,* 2011). The commonly known species in all 14 is *Moringa oleifera* (Jideani *et al.,* 2014; Mbikay, 2012). *Moringa oleifera* originated from South Asia, in the Himalayan foothills, located from north-eastern Pakistan to Northern West Bengal in India but *Moringa oleifera* is now found in many parts of the world such as Afghanistan; Bangladesh; Sri Lanka; west Asia; east, south and west Africa; south Florida; west Indies; Mexico; Peru; Brazil and Paraguay (Fahey, 2005).

2.7.1 Physical characteristics of the *Moringa oleifera* tree

The *Moringa oleifera* tree is a deciduous slender tree with branches of light to dark green droopy leaves (Figure 2.2). The flowers are creamy-white and are mildly fragrant. Pods from the tree are long and triangular, containing approximately 20 seeds per pod. Each seed is covered in three paper-like wings which serve as a propeller. Flowers, pods and seeds are produced throughout the year (Palada, 1996).

The pods which are said to be like green beans, are canned and exported from India, Sri Lanka and Kenya to Asia and Europe (Price, 2007). Green seeds from the pods can be removed from the pod casing and either boiled or fried in a similar manner as with peas. Dry seeds are not eaten by humans but rather utilized for different industrial and agricultural applications (Price, 2007). The tree begins to flower after being planted for approximately 8 to 12 months. Flowering continues throughout the year (Figure 2.2). The flowers have been used in Haiti to prepare tea used to treat colds (Price, 2007).

Moringa oleifera branches are soft and can easily be bent. The branches can been used to make fences or trees can been grown around the perimeter of a house/shack as a form of “live fencing” (Price, 2007). Fresh young leaves are eaten in a similar manner to spinach (Joshi & Mehta, 2010). The roots from young *Moringa oleifera* trees can be harvested and

substituted for horse radish, hence one of the alternative names for *Moringa oleifera.* The bark covering the root must first be removed before being eaten. Consumption of the root should be limited as excess can be harmful (Price, 2007).

2.7.2 Growing conditions and reproduction of *Moringa oleifera* tree

The growing conditions most suited to *Moringa oleifera,* is in hot, semi-arid tropics. The tree is drought tolerant; however, excessively windy conditions may result in the tree drying out (Figure 2.2). The recommended amount of rainfall is 10-60 inches per year and the most preferred altitudes range from 600 m to 1200 m (Price, 2007; Broin & Saint Sauveur, 2010). The tree can withstand light frost; should there be extreme frost, a mature tree may die but the tree is capable of re-growing. *Moringa oleifera* trees can survive in most soil types but the tree prefers loam or well drained sandy soil (Price, 2007).

Figure 2.2: *Moringa oleifera* stem with leaves and flowers (Agyepong, 2009)

Moringa oleifera trees grow rapidly and can reach up to 4 m per year, with a maximum height of between 6-15 m once fully grown. Periodical pruning encourages new growth with an abundance of leaves that are easily accessible for harvesting (Price, 2007; Palada, 1996). Another reason that can make *Moringa oleifera* to be called a "miracle tree" besides its nutritive value could be that even during the dry season, the tree still has full leaves, when food sources are exhausted especially in tropical areas (Mishra *et al.,* 2012).

Propagation of *Moringa oleifera* can easily be done from seed or via cuttings. Germination of the seeds usually occurs within 1-2 weeks. Shaded conditions yield the best germination rates. Cuttings can successfully be grown to produce healthy trees. The recommended length is 45-100 cm of a healthy stem. The preferred method of propagation is by seeds or seedlings as cuttings tend to have a shorter root system which may affect the anchoring ability of the tree in windy conditions (Price, 2007; Broin & Saint Sauveur 2010).

2.7.3 Harvesting and drying of *Moringa oleifera* leaves

Moringa oleifera leaves, both mature and young, can be dried to make *Moringa oleifera* leaf powder. But the drying conditions of leaves is very important for safety of the final product. But before the leaves are dried, healthy; disease free; fungi free leaves with a dark green colour must be manually selected. The washing process of *Moringa oleifera* leaves is in four stages where the leaves are first washed in clean water, then soaked in 1% saline solution (NaCl) for 5 minutes, thereafter the leaves are dipped in 70% ethanol and finally rinsed with distilled water (Mishra *et al.,* 2012).

The leaves must be dried, they can either be shade dried, sun dried or oven dried but the type of drying method is important for nutrient preservation. A study by Josh & Mehta (2010) showed that shade drying retained more nutrients in comparison to sun drying and oven drying. When the leaves are shade dried, it is important that they are dried in a sterile, well ventilated room and covered with nets e.g. mosquito nets. For uniform drying the leaves should be turned over, and the personnel responsible for this should have personal protective equipment e.g. sterile gloves to prevent contamination of the leaves (Mishra *et al.,* 2012).

Then the leaves can be grinded, to make *Moringa oleifera* leaf powder. A further stage of drying at 50°C for 30 minutes is required after grinding because the powder is highly hydroscopic. The *Moringa oleifera* leaf powder can be stored for 6 months at 24°C in airtight or vacuum sealed containers, preferably away from light and humid surroundings (Mishra *et al.,* 2012).

2.7.4 Nutritive value of *Moringa oleifera*

A 100 g of fresh *Moringa oleifera* leaves contains seven times the vitamin C of oranges, four times the vitamin A of carrots, four times the calcium of milk, three times the potassium of banana, and two times the protein of yoghurt (Fahey, 2005). Powdered *Moringa oleifera* leaves have increased micronutrient content of ten times the vitamin A of carrots, seventeen times the calcium of milk, fifteen times the potassium of bananas, twenty-five times the iron of spinach, nine times the protein of yoghurt but the vitamin C content decreases to half that of an orange (Fuglie, 2001; Hekmat *et al.,* 2015). When comparing the nutritive value of *Moringa oleifera* pods, fresh leaves and leaf powder as shown in Table 2.7, it is evident that *Moringa oleifera* leaf powder has increased nutrient content, in almost all the macro and micronutrients required by the human body, in comparison to pods and fresh leaves.

Table 2.7: Nutritional value of *Moringa oleifera* pods, fresh leaves and leaf powder per 100 g (Fuglie, 2001)

Parameter	**Pods**	**Fresh leaves**	**Leaf powder**
Moisture (%)	86.9	75.0	7.5
Calories	26.0	92.0	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrate (g)	3.7	13.4	38.2
Fibre (g)	4.8	0.9	19.2
Minerals (g)	2.0	2.3	-
Ca (mg)	30.0	440.0	2003.0
Mg (mg)	24.0	24.0	386.0
P (mg)	110.0	70.0	204.0
K (mg)	259.0	259.0	1324.0
Cu (mg)	3.1	1.1	0.6
Fe (mg)	5.3	7.0	28.2
S (mg)	137.0	137.0	870.0
Oxalic acid (mg)	10.0	101.0	0.0

Table 2.7: Nutritional value of *Moringa oleifera* pods, fresh leaves and leaf powder per 100 g cont. (Fuglie, 2001)

Parameter	Pods	Fresh leaves	Leaf powder
Vitamin A- Beta carotene (mg)	0.11	6.8	16.3
Vitamin B (mg)	423.0	423.0	-
Vitamin B1 (mg)	0.05	0.21	2.6
Vitamin B2 (mg)	0.07	0.05	20.5
Vitamin B3 (mg)	0.2	0.8	8.2
Vitamin C (mg)	120	220.0	17.3

Moringa oleifera leaves are also good sources of phytonutrients such as carotenoids, tocopherols and ascorbic acid. These nutrients are known to scavenge free radicals when combined with a balanced diet and may have immunosuppressive effects (Saini *et al.,* 2014a, 2014b). *Moringa oleifera* leaves have been used as an alternative food source to combat malnutrition, especially among children and infants (Anwar *et al.,* 2007). Children aged 1-3 years can obtain 23%, 40% and 14% of their Recommended Dietary Allowance (RDA) for iron, calcium and protein; respectively, from 8 g of *Moringa oleifera* leaf powder (Mishra *et al.,* 2012). While Thurber & Fahey (2009), found that children from 1-8 years can obtain almost all their RDA for Vitamin A, calcium, iron and protein in 24 g of *Moringa oleifera* leaf powder (Table 2.8).

Table 2.8: Daily recommended dietary allowance for children especially those between the ages of 1-5 years old (Thurber & Fahey, 2009)

Nutrients	Fresh leaves (value/100g edible portion)	Dried leaves (value/24g approx. 3Tbsp) edible portion	RDA for healthy children aged 1-8 years old
Calories	92 cal.	49 cal.	
Macronutrients			
Protein	6.70 g	6.5 g	13-19g/day
Fat	1.70 g	0.55 g	30-40g/day
Carbohydrates	12.5 g	9.2 g	130g/day
Micronutrients			
Carotene (Vitamin A)	6.78 mg	4.54 mg	.3 - .4 mg/day
Calcium	440 mg	480. 72 mg	500-800 mg/day
Iron	0.85 mg	6.77 mg	7-10 mg/day
Vitamin C	220 mg	4.15 mg	15-25 mg/day
Zinc	0.16 mg	.79 mg	3-5 mg/day

2.7.5 Consumer acceptability of *Moringa oleifera* fortified foods

The use of *Moringa oleifera* leaf powder in fortifying foods is on the rise in many African countries such as Ethiopia, Malawi, East Africa and Ghana where both fresh and dried leaves are utilised (Agbogidi & Ilondu, 2012)**.** Consumer acceptability of foods fortified with *Moringa oleifera* leaves (both fresh and dried forms) is shown in Table 2.9 and from these studies it was evident that *Moringa oleifera* leaf powder fortified foods were acceptable but up to certain concentrations mainly due to colour changes.

Table 2.9: A summary on consumer acceptability of *Moringa oleifera* (fresh or dried leaves) fortified foods

Authors	Type of study	Study area	Food tested	Findings
Babu (2000)	Consumer acceptance (50 rural households)	Malawi	**Five relish foods** -*Moringa oleifera* fresh leaves boiled with salt -*Moringa oleifera* fresh leaves boiled with salt & chillies -*Moringa oleifera* fresh leaves boiled & fried with salt and chillies -*Moringa oleifera* fresh leaves boiled with beans -*Moringa oleifera* fresh leaves boiled with meat	-Sixty three percent of participants preferred *Moringa oleifera* relish foods over pumpkin leaves -The most preferred *Moringa oleifera* dishes were *Moringa oleifera* fresh leaves boiled with beans; *Moringa oleifera* boiled and fried with salt and chillies.
Nambiar *et al,* (2003)	Feasibility and acceptability of incorporating dehydrated drumstick leaves into preschool meals (60 children)	India	**Four salty snacks called:** -Boiled chana -Moong -Poha -Dhokla	-Forty children aged 1-5 years were given 5-7 g of drumstick or *Moringa oleifera* dried leaf powder and their acceptability was not different from the acceptability of the control group (n=20) who received regular snacks.
Nadeem *et al,* (2012)	Sensory evaluation (75 ladies from different villages)	Pakistan	**Buttermilk** with varying concentrations of *Moringa oleifera* leaf powder (MOLP) at 1%, 2%, 3% and a control	-Addition of MOLP at 2% (T2) level did not have any significant effect on colour, taste and overall acceptability scores. -The overall acceptability score at 3% (T3) was 6.7 out of 9, which is equivalent to 74%.

Table 2.9: A summary on consumer acceptability of *Moringa oleifera* (fresh or dried leaves) fortified foods cont.

Authors	Type of study	Study area	Food tested	Findings
Madukwe *et al,* (2013)	Sensory evaluation (60 undergraduate students)	University of Nigeria (Nsukka)	**Beverage** Sample 1: *Moringa oleifera* leaf powder extract Sample 2: extract from popular tea leaves (Lipton) Sample 3: equal mixture of both *Moringa oleifera* leaf extract and Lipton extract	-*Moringa oleifera* beverage was more acceptable than Lipton (control) in terms of flavor and overall acceptability ($p < 0.05$) -There was no significant difference between the taste of *Moringa oleifera* beverage and Lipton tea ($p > 0.05$).
Nadeem *et al,* (2013)	Sensory evaluation (panel of 5-trained judges)	University of Veterinary and animal sciences – Lahore, Pakistan	**Butter** *Moringa oleifera* leaf extract incorporated into butter at 400 ppm, 600 ppm, 800 ppm and there was a control	-Addition of *Moringa oleifera* leaf powder extract up to 600 ppm (T2) level did not have any negative effect on taste, smell and colour scores -The overall acceptability score for 600 ppm was 7.2 out of 9 (equivalent to 80%) -But *Moringa oleifera* leaf powder extract of up to 800 ppm decreased the score for overall acceptability.
Nwosu Odinakachukwu *et al,* 2014	Sensory evaluation (30 mothers)	Mother and Child Health Clinic and Motherless Babies home (Nigeria)	**Infant complementary foods** made from maize: soybean (60: 40) = control diet and maize: soybean: *Moringa oleifera* leaf (60: 30: 10) = test diet	-The diets had comparable flavor, texture and general acceptability scores but colour scores differed ($p < 0.05$).

Table 2.9: A summary on consumer acceptability of *Moringa oleifera* (fresh or dried leaves) fortified foods cont.

Authors	Type of study	Study area	Food tested	Findings
Kuikman *et al,* (2015)	Consumer Test (37 participants)	District of Mabatini in Mwanza, Tanzania	**Yogurt** with five samples -probiotic yogurt (control) -*Moringa oleifera* probiotic yogurt -*Moringa oleifera*-banana probiotic yogurt -*Moringa oleifera*- sweet potato probiotic yogurt -*Moringa oleifera*-avocado probiotic yogurt	-*Moringa oleifera*-probiotic yogurt; *Moringa oleifera*-sweet potato and *Moringa oleifera*-avocado had comparable scores to probiotic yogurt (acceptability was equal), but *Moringa oleifera*-banana probiotic yogurt was more acceptable (had higher score across all sensory attributes) than *Moringa oleifera*-probiotic yogurt.

Moringa oleifera in South Africa has been classified by the Department of Agriculture Forestry and Fisheries (DAFF), (2013) as a medicinal plant, mostly grown in Limpopo Province, Free State, Mpumalanga, KwaZulu-Natal and Gauteng. There is, however a current shift from the use of *Moringa oleifera* leaf powder for medicinal purposes (headache, diarrhoea, wounds or insect bites) to utilizing it as food. The Lammangata *Moringa oleifera* project has documented a case study of how *Moringa oleifera* leaf powder was utilized in Limpopo to address malnutrition in children (Lekgau, 2012). A study by Agyepong (2009) showed that in Limpopo, 4.5% of participants added chicken to *Moringa oleifera* dishes containing fresh leaves while 9% prepared *Moringa oleifera* fresh leaves with red meat.

2.8 Summary

Moringa oleifera leaf powder can be a possible food fortificant for children because of its nutritive value especially in snack foods, since healthier snacks or foods are considered to be expensive by caregivers especially in rural areas or otherwise disliked by children or caregivers lack nutritional knowledge. It was therefore imperative for this study to develop snacks fortified with *Moringa oleifera* leaf powder as a form of vegetable to assess the effect of *Moringa oleifera* leaf powder on nutritive value of the snack prototypes and on consumer acceptability of *Moringa oleifera* snack prototypes as presented in the following chapter.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Chapter three elaborates on the methods and procedures that were followed in achieving research objectives for this study. The outline for this chapter includes the study conceptual framework (Figure 3.1); description of the study area; research methodology which includes the study design, sample population, sample selection, data collection, validity and reliability of methods, data analysis and ethical clearance.

3.2 Study conceptual framework

The study conceptual framework was adopted from Khoza (2014) and is showcasing food and nutrition security pillars that contribute towards improved and or enhanced well-being. Figure 3.1, demonstrates how *Moringa oleifera* leaf powder-based snacks could possibly contribute towards improved nutritional status of children.

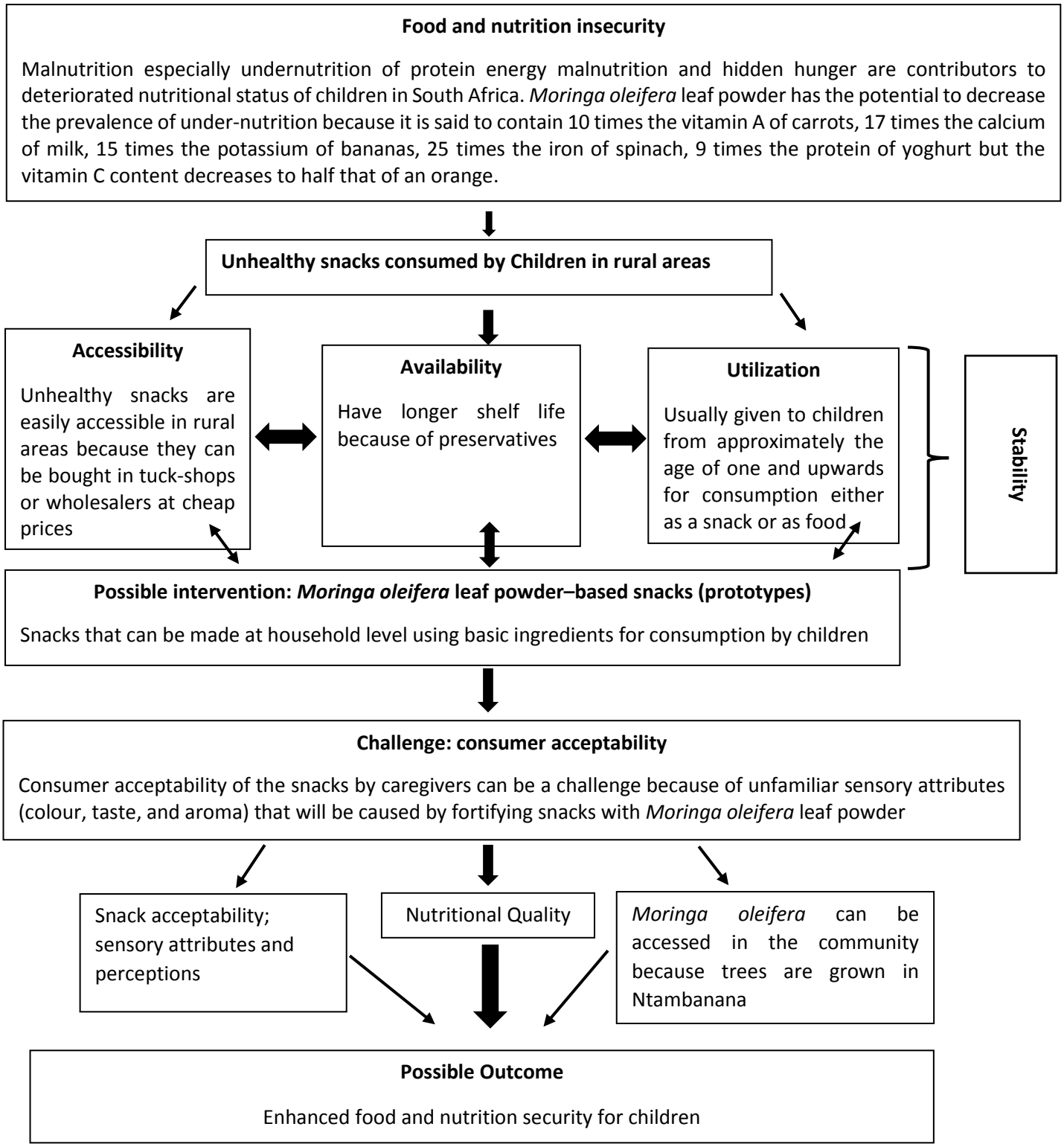

Figure 3.1: Adapted enhanced food and nutrition security for children conceptual framework (Khoza, 2014).

3.3 Description of the study area

The study was conducted in Ntambanana, which is a local municipality under the uThungulu District in KwaZulu-Natal. The geographical size of the municipality is estimated to be 1083 km^2 with 92 659 inhabitants (Department of Health (DOH), 2014/15). Ntambanana has four rural areas that are governed by the traditional council and eight wards that are governed by the municipality. The study was conducted in a rural area called Buchanana as shown in Figure 3.2. The area is characterized by high unemployment rates and poverty which mainly affects the youth and children under five years of age. Health services that are in Ntambanana cannot satisfactory provide necessary and sufficient health care for the community and malnutrition has been put at third position as a leading cause for child and adult morbidity (Ntambanana IDP, 2013/4; DoH, 2014/15).

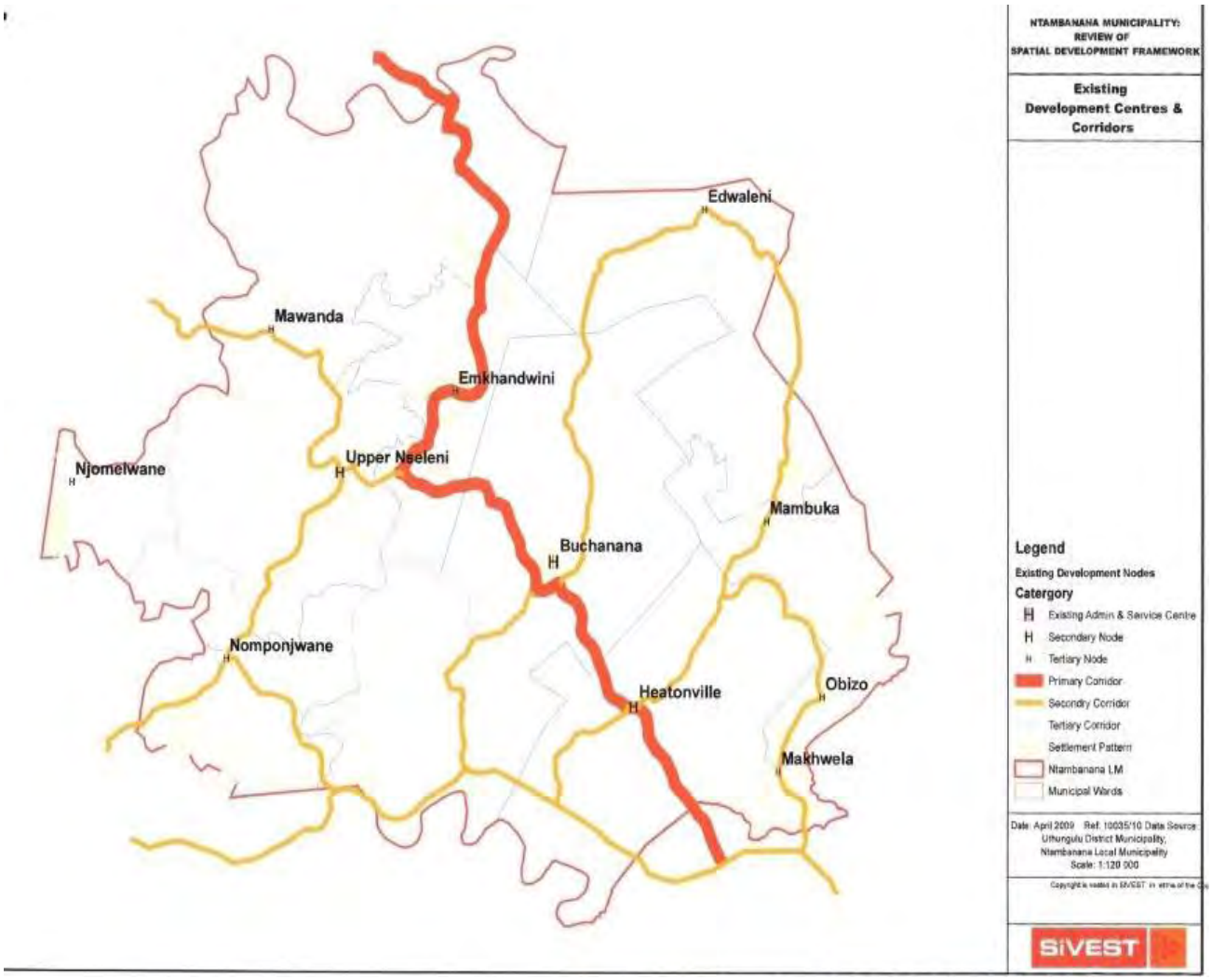

Figure 3.2: Map of Ntambanana (Ntambanana IDP, 2013/4)

Approximately 60% (56 763) of the population lives in poverty and that puts Ntambanana at third position for being the most deprived municipality out of 52 municipalities in KwaZulu-Natal. Approximately 3024 people are employed for intensive labour in the agriculture, hunting, forestry and fishery industry and obtain a minimum wage to feed and maintain households made up of approximately five to six members (Ntambanana IDP, 2013/4).

3.4 Methodology

3.4.1 Research technique

A mixed research method was used in this study and it has been put to practice for many years by researchers and refer to it with various names such as integrated, combined, multi-method (Driscoll *et al.,* 2007). A mixed research method can be defined as a methodology of conducting research that involves collecting, analysing, and integrating (or mixing) quantitative and qualitative research in a single study or a longitudinal program of inquiry. Using the mixed research method allows the researcher to obtain clearer understanding of the research problem or issue that is researched which when choosing to use a single approach alone would not be understood better (Creswell, 2013).

The advantages of using mixed research method are that it helps researchers compare any similarities or differences between qualitative findings and quantitative results. It allows the opinions of participants to come forth on that particular subject or object of study. It also allows research designs to be more flexible thus allowing for more complete data to be collected than using a single approach. The mixed research method requires multifaceted planning and implementation; a multidisciplinary team of researchers that are willing to be open minded in working together for the success of the research and time because it is labour intensive (Wisdom & Creswell, 2013).

3.4.2 Study design

A convergent parallel mixed research design was followed for this study, and it is a type of design that allows for qualitative and quantitative data to be collected in parallel, analysed separately and then the results to be merged together (Creswell, 2013).

3.4.2.1 Sample population

The sample population for the study was 77 caregivers for the survey, 60 panelists for sensory evaluation and 12 caregivers for four focus group discussions. Caregivers with children in pre-primary school (popularly known as crèches) with ages between 1-5 years were the target population for the study, because literature has shown that undernutrition is most prevalent in this age group in South Africa (Shisana *et al.,* 2013). Caregivers gave informed consent that was created in English (Appendix B) and translated to IsiZulu (Appendix C) during sensory evaluation after it was indicated to them that the samples contained *Moringa oleifera* leaf powder because it has not been approved for human consumption, thus targeting children would be unethical and illegal (Mbikay, 2012).

3.4.2.2 Sample selection

For the survey part of the study a non-probability (non-experimental) sampling method following a random purposive sampling technique to select caregivers who were having children under 5 years of age in their households was used. House-to-house knocking and referrals were done to aid with the obtainment of participants.

Panelists for sensory evaluation were recruited during the survey and letters were also written and given to children in pre-primary schools (Luwamba crèche and Sobokwe crèche) to take home to their caregivers. For focus group discussions, the participants from the sensory evaluation were further invited to participate in focus group discussions. A series of four focus group discussions with 10-12 group members were conducted.

3.5 Data collection

3.5.1 Survey

An English (Appendix D) questionnaire interpreted to IsiZulu (Appendix E) was used as a data collecting instrument for the survey and comprised of closed ended and open ended questions. The questionnaire was divided into four sections of socio-demographic information; snacks consumed by children; vegetable consumption with meals and utilization of *Moringa oleifera* leaf powder.

3.5.2 Preparation of snacks

The snack prototypes were first developed at the foods laboratory of the Department of Dietetics and Human Nutrition at the University of KwaZulu-Natal, Pietermaritzburg under the supervision of a Food Scientist, who helped with recipe development before replication during data collection. Tortilla chips were developed as *Moringa oleifera* leaf powder snack prototypes because they resemble similar characteristics as popular commercial chips consumed by children. However, in the current study, the recipe used cost-effective basic household ingredients.

The cooking method of deep fat frying was also familiar to rural households such as those found in Ntambanana because they make fat cakes (*amagwinya*) which are also popular. A triangular shape of tortilla chips was deemed to be attractive to children (1-5 years), more so there are commercial chips with similar shape. A standard recipe (Appendix F) for flour tortillas was used and the quantities of ingredients, which were bought at the local supermarket, were converted to grammes for ease of use and accuracy.

3.5.2.1 Conversion of volume (ml) measurements of ingredients into mass (g)

1 cup (250 ml) = 132 g wheat flour

1 teaspoon (5 ml) = 6 g salt

1 teaspoon (5 ml) of baking powder = 11 g

- Therefore 2 teaspoons = 22 g

1 teaspoon (5 ml) margarine = 6 g (there are 3 teaspoons in 1 tablespoon)

- Therefore 6 g x 3 = 18 g (2 tablespoons)

1 ½ cups of water = 250 ml + 125 ml = 375 ml water

3.5.2.2 Substitution of maize flour with wheat flour

Nixtamalized maize flour is usually used to make tortilla chips (Gomez *et al.,* 1992) but for this study un-nixtamalized white maize was milled into flour with particle size of 200 µm using a pilot roller mill (GB 12350 Leshan Dongchuan Machinery Co. Ltd). This resembles the local maize processing method which is popular especially to rural areas who still rely on agriculture for food security.

Maize was mixed with wheat flour as a binding agent because maize has no gluten. Wheat flour was incorporated gradually at 10%, 20%, 30% and 50% (w/w) substitution with white maize meal as shown in Figures 3.3-3.7, and at 50% wheat flour and 50% maize flour the dough seemed to be of acceptable quality.

Figure 3.3: Dough at 10% wheat flour content

Figure 3.4: Dough at 20% wheat flour content

Figure 3.5: Dough at 30% wheat flour content

Figure 3.6: Dough at 40% wheat flour content

Figure 3.7: Dough at 50% wheat flour content (acceptable)

3.5.2.3 Fortification of wheat and maize flour with *Moringa oleifera* leaf powder

Moringa oleifera leaf powder (MOLP) ratio to the mixture was incorporated at lower intervals of 1%; 3% and 5% (w/w substitution) as a baseline. The calculations were as follows:

The calculations were as follows:

264 g wheat flour + 475. 2 g maize flour = 739. 2 g (total)

739. 2 g / 100 x 1 = 7. 392 g

- Approx. = 7. 4 g of MOLP content at 1%

739. 2 g / 100 x 3 = 14. 784 g

- Approx. = 14. 8 g of MOLP content at 3%

739. 2 g / 100 x 5 = 36. 96 g

- Approx. = 36. 9 g of MOLP content at 5%

Thereafter calculations of substituting flour (wheat + maize) with MOLP to make experimental doughs were calculated as follows:

264 g wheat flour + 475. 2 g maize flour = 739. 2 g (total)

0% MOLP (control) = 739. 2 g flour (wheat + maize flour)

1% MOLP (experimental): 739. 2 g flour – 7. 4 g MOLP = 731. 8 g flour

3% MOLP (experimental): 739. 2 g flour – 14. 8 g MOLP = 724. 4 g flour

5% MOLP (experimental): 739. 2 g flour – 36. 9 g MOLP = 702. 3 g flour

A green colour was notable from slightly green at 1% to moderately green at 3% and very green at 5%, as the *Moringa oleifera* leaf powder (MOLP) content increased as shown in Figures 3.8-3.10.

Figure 3.8: Dough with 1% MOLP

Figure 3.9: Dough with 3% MOLP

Figure 3.10: Dough with 5% MOLP

The doughs were rolled out, cut into triangular shapes and deep fat fried. After recipe development trials, the recipe was replicated at the study site in preparation for sensory evaluation. Figures 3.11- 3.13 show the *Moringa oleifera* leaf powder snack prototypes.

Figure 3.11: Tortilla snack at 1% MOLP content

Figure 3.12: Tortilla snack at 3% MOLP content

Figure 3.13: Tortilla snack at 5% MOLP content

3.5.2.4 Quality analysis of the *Moringa oleifera* leaf powder (MOLP) snack prototypes

The quality of MOLP snack prototypes was analyzed through colour measurements, texture measurements and nutritional composition analysis as follows:

- Colour

The colour of the MOLP snack prototypes was measured in triplicate using a pre-calibrated Hunter Lab colorimeter (Hunter Associates Laboratory, Inc., Reston, VA). The prototypes were placed on the centre of a dry and clean glass sample cup, placed in a sample port, then covered and readings taken (Rao *et al*., 2011). The readings were recorded as Hunter Lab values where L* (100 = white; 0 = black) is an indication of lightness; a* measures chromaticity, with positive values indicating redness and negative values indicating greenness; while b* measures chromaticity, with positive values indicating yellowness and negative values indicating blueness.

- Texture

A crisp Fracture Rig probe (HDP/CFS) was used to analyse the breaking force of MOLP snack prototypes as an indicator for hardness, using a Texture Analyzer TA-TX2 (Stable Microsystem, Surrey, England) equipped with a 5 kg load cell. The peak breaking force (g) of snacks using the force-in-compression was recorded. The analyzer was set at a return-to-start cycle, with a pretest speed of 3 mm/s, test speed of 1 mm/s, post-test speed of 10 mm/s, the trigger force was 10 g at 6 mm. Ten randomly selected snacks from each variety were analysed for hardness.

- Nutritional analysis

The samples were prepared, and then freeze dried in preparation for nutritional analysis. Using standard methods of nutritional analysis, the samples were analysed in duplicate at CEDARA, Pietermaritzburg for moisture, total mineral content (ash), fat, ADF (Acid Detergent Fibre), NDF (Neutral Detergent Fibre), crude protein and individual mineral contents. A brief description of how each of the nutrients was determined is given below.

Moisture content

The moisture content of samples was determined according to the AOAC method, (1990). Exactly 2 g of each of the samples was weighed into clean, dry pre-weighed crucibles. The samples were dried in a hot-air drying oven at 105 °C for 3 hours. The dried samples were transferred into a desiccator and allowed to cool to a constant weight. The dried sample weights were recorded and the differences in weight was calculated as a percentage of the original sample.

$$\% \text{ moisture content} = \frac{w2 - w1}{w2 - w3} * 100$$

Where w1 = initial weight of empty dish, w2= weight of dish + un-dried sample, w3 = weight of dish + dried sample.

Total mineral content

Ash content was measured according to the AOAC official method 942.05 (AOAC, 2003).

Fat

The fat content was analysed using soxhlet procedure following AOAC official method 920.39 (AOAC, 2002).

Fibre

The fibre content of the samples was determined as acid detergent fibre (ADF) and neutral detergent fibre (NDF). The ADF was determined following AOAC official method 973.18 and NDF was determined using the AOAC official method 2002.04 (AOAC, 2002).

Crude protein

The crude protein content was measured using the Dumas method as described in the AOAC official method 1990 (Sader *et al.,* 2004).

Individual mineral elements

Calcium, magnesium, sodium, potassium, zinc, copper, manganese and iron were determined following the AOAC official method 6.1.2 (AOAC, 1984).

3.5.3 Sensory evaluation

3.5.3.1 Sample coding, serving order and sensory evaluation set-up

To reduce bias associated with the labelling of samples, a table of random numbers was used to assign each sample a unique three-digit code. The samples were tested in a randomized order from left to right. Randomization of the serving order was done using a Table of Random Permutations of Nine. To prevent panelists from influencing each other's responses, they were made to sit apart with their backs turned from each other

Before the sensory evaluation began, panelists were asked to sign the informed consent form (Appendix B) which was thoroughly explained to participants in their local language before they signed. All participants were provided with a glass of water, serviette, and small platter containing a single sample per platter. A five-point pictorial hedonic scale was used to collect data for sensory evaluation of snack prototypes, the questionnaire was created in English (Appendix G) but panelists used the IsiZulu version (Appendix H). A five-point hedonic scale was used to indicate whether consumers disliked very much, disliked slightly, neither liked nor disliked, liked slightly and liked the colour very much, aroma, crunchiness, taste and overall acceptability of each sample.

3.5.4 Focus group discussions

An interview guide (Appendix I) was used for focus group discussions, the interviews were conducted in IsiZulu language to gather perceptions of participants about food and nutrition security, snacks given to children and the knowledge they have about *Moringa oleifera* leaf powder. After each focus group discussion, verification of information was conducted and there were two sessions in the morning and afternoon in both pre-primary schools (Luwamba and Sobokwe) to avoid fatigue. A trained facilitator who spoke the local language conducted the focus group discussions (Figure 3.14) and each focus group discussion took about an hour to an hour and a half. While the focus group discussions were in progress, they were recorded using an audio recorder and transcribed on a white board paper.

Figure 3.14: Session during focus group discussions

3.6 Validity and reliability of methods

A rapid rural appraisal and orientation of the area was conducted before the actual data collection. All the questionnaires were created in English, approved by supervisors and then interpreted to IsiZulu by the researcher who spoke the same language, it was further confirmed by the local study area research assistant to ensure clarity or correct context in IsiZulu. Field workers were trained over two days and were monitored by the researcher during data collection for the survey; setting up the venues for sensory evaluation and focus group discussions.

3.7 Data analysis

The Statistical Package for Social Sciences (IBM SPSS), version 21, was used to generate descriptive statistics, to perform ANOVA and to obtain inferential statistics using Dunnet and Tukey tests ($p<0.05$). Focus group discussions were analysed by transcribing and linking of themes, concepts, patterns and quotes which emerged from the discussions.

3.8 Ethical clearance

The agriculture department under the Luwamba Centre in Ntambanana gave permission for this study (Appendix J). The University of KwaZulu-Natal Humanities, and Social Science Research Ethics Committee provided ethical clearance for this study with the following ethical clearance number: HSS/0781/015M (Appendix K).

CHAPTER 4: RESULTS OF THE STUDY

4.1 Introduction

In chapter four the results of the study that were obtained through quantitative and qualitative methods will be deliberated.

4.2 Socio-demographic information

Most caregivers (85%) were females between 50 and 57 years of age, and their role to children was that of a parent (58%). More than a third of caregivers (35%) had no formal education and 76% were unemployed. The source of income for 36% of caregivers was from pension grants with household income per month for 53% of caregivers ranging from R801.00-R1500.00). For 22% of caregivers, their households consisted of six household members, while 26% of caregivers were living in four roomed houses with their families. Over 50% of children were found to be one-year-old. The results of the study also showed that 63% and 67% of children never suffered from diarrhoea and constipation, respectively.

4.3. Snacks given to children

The following results seek to answer objective one, which was about snacks commonly given to children in Ntambanana. Eighty seven percent of caregivers claimed to give their children snacks daily. The kinds of snacks that were mostly given to children by caregivers were savoury snacks (73%), fruit (53%), dairy snacks (46%) and sugary snacks as shown in Figure 4.1. The type of savoury snack mostly given to children by caregivers was Jiggies with a serving size of 20 g. Jiggies is a brand name for extruded savoury snacks that have barbecue, tomato, and cheese flavours. A fruity snack popularly given to children by caregivers was one whole apple (138 g). A 100 g of danone was a dairy snack that was frequently given to children. In the sugary category of snacks,

Marie biscuits were mostly given to children by caregivers with an average serving size of five biscuits (1 biscuit = 6 g).

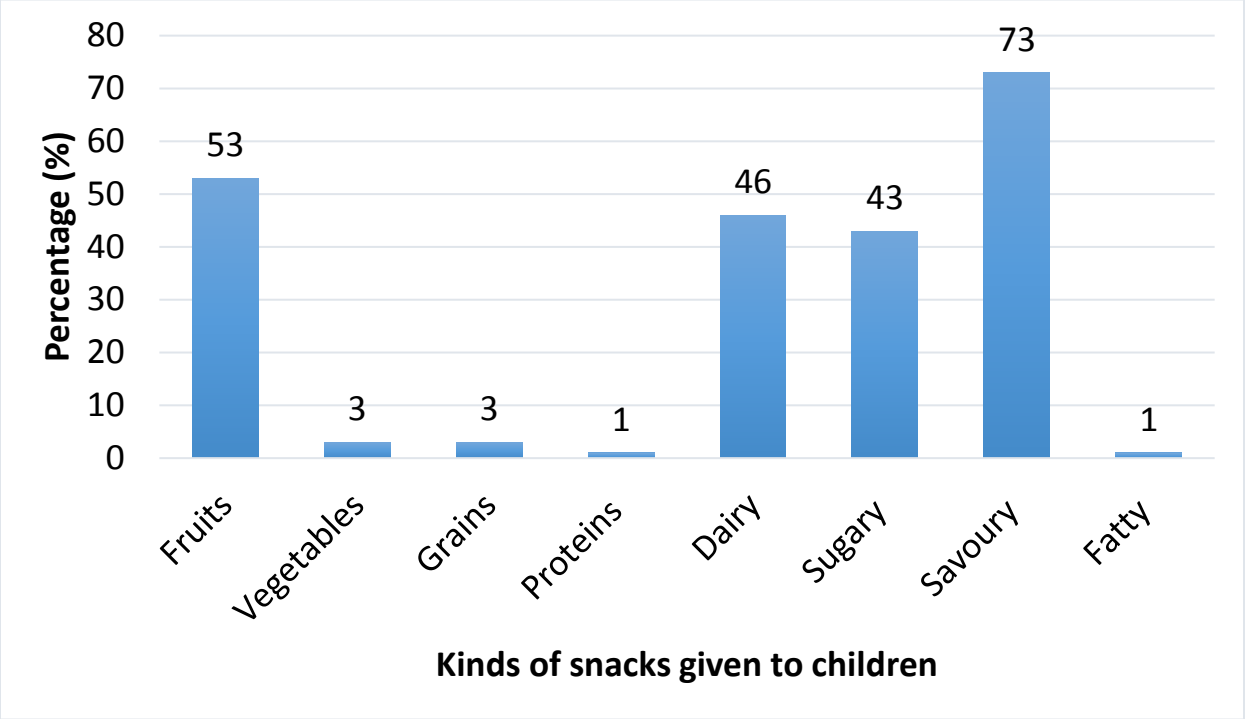

Figure 4.1: Snacks that are mostly given to children in Ntambanana (N=77)

The results showed that snacks were given at lunch, midmorning and at breakfast; savoury snacks were given to children with percentages of 22, 16, and 14; respectively. Savoury snacks were mostly introduced to children between the ages of three to four years by 23% of caregivers and four to five years by 25% of caregivers. Sugary snacks were frequently given to 18% of children between the ages of two to three years. Fruit consumption decreased as the age categories of children increased with 65% of children older than four and five years given less fruit. The reasons caregivers gave children snacks were to make them happy (46%) and because children liked snacks (20%). The amount of money spent by 58% of caregivers in purchasing snacks per child, per week was more than ten rands.

4.4 Vegetable consumption with meals

Only three percent of caregivers said they give children vegetables as snacks but this was compensated with by 88% of caregivers who gave children vegetables as part of meals. Leafy vegetables were given to children by 73% of caregivers, as shown in Figure 4.2.

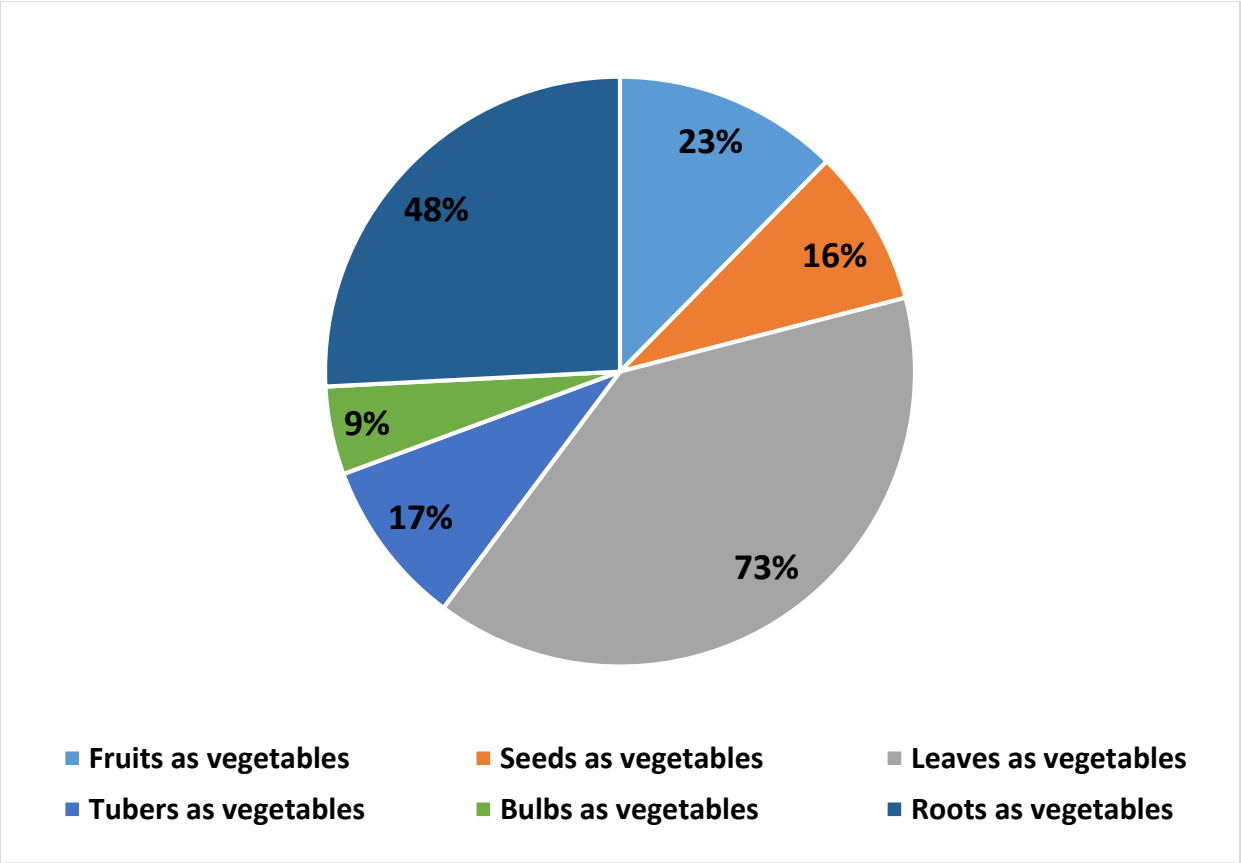

Figure 4.2: Vegetables mostly given to children

Children were given three servings of different kinds of vegetables per day which were cabbage (26%), potatoes (10%) and carrots (26%). A majority of 55% of caregivers said they do not have food gardens at home.

4.5 Utilization of *Moringa oleifera* leaf powder

Only a minority of caregivers (10%) were familiar with *Moringa oleifera* leaf powder (MOLP). Of the 10% that were familiar with MOLP, 5% received the information from Luwamba centre (where *Moringa oleifera* was planted). *Moringa oleifera* leaf powder was mainly used for the following medicinal purposes; strength or wellbeing, stamina, to stimulate appetite, for skin problems and for stomach ailments. *Moringa oleifera* leaf powder was taken regularly for at least once a week and occasionally at least once a month.

Only four percent of caregivers said they were familiar with the use of MOLP in food and they used MOLP as a beverage (used as tea), a herb in meat dishes, others sprinkled MOLP in ready to eat food and others sprinkled MOLP into food while cooking. When caregivers were asked if they could use MOLP for nutritional benefits when encouraged to use it, 48% said they would happily use it and 64% would be willing to include or incorporate MOLP in the current home-made snack for their children. The reason caregivers would be willing to incorporate MOLP for 27% into snacks for their children was be for its acclaimed nutrient content but a lack of scientifically proven information for 23% of caregivers would make them not to put MOLP in snacks for their children.

4.6 Food product development results

The student and supervisors decided to fortify tortilla chips with *Moringa oleifera* leaf powder (MOLP) because the recipe (Appendix F) uses basic household ingredients which are affordable; the cooking method of deep fat frying is convenient for rural households such as those found in Ntambanana and the triangular shape of the tortilla chips could be attractive to children (1-5 years). The quality of the snack prototypes was measured through colour measurements, texture measurements and nutritional composition analysis to achieve objective two of this study.

4.6.1 Colour

In this study, the colour of the prototypes was affected by the addition of MOLP. The snacks changed from a normal light brown (control) colour expected for chips to a dark green colour with traces of light brown, as the concentration of MOLP increased in the formulation. This effect was also confirmed by the Hunter lab colorimeter results (Table 4.1). The L* values (lightness, 0 = black, 100 = white) decreased as the MOLP content increased, while a* values also decreased towards –a* (+*a** = redness and – *a** = greenness). The L* mean values ranged from 60.12 – 48.12 while b* mean values varied from 6.21 – 1.66.

Table 4.1: Effect of *Moringa oleifera* leaf powder (MOLP) on the colour of wheat-maize snacks

Snack type	Colour (Hunter Lab values)		
	L*	a*	b*
0% MOLP* (control)	60.12 ± 0.18^{a}	6.21 ± 0.23^{a}	30.40 ± 0.21^{a}
1% (7.4 g) MOLP	49.38 ± 0.34^{be}	5.81 ± 0.20^{b}	27.96 ± 0.20^{be}
3% (14.8 g) MOLP	48.86 ± 0.48^{ce}	2.25 ± 0.06^{c}	28.37 ± 0.19^{ce}
5% (36.9 g) MOLP	34.13 ± 0.17^{d}	1.66 ± 0.08^{d}	13.25 ± 0.34^{d}

Means ± SD. Mean values followed by different superscript letters in the same column are significantly different at $p<0.05$, determined by Tukey test. L* = lightness (0 black to 100 = white), a* = redness to greenness (+*a** = redness and – *a** = greenness), and b* = yellowness to blueness (+*b** = yellowness; -*b** = blueness). MOLP*: *Moringa oleifera* leaf powder.

4.6.2 Texture

The breaking force of snacks can be considered the maximum force needed to break the snacks, thus giving a clear picture of snack hardness (Abdela-shafi & Abdulla, 2014). As shown in Table 4.2 as the *Moringa oleifera* leaf powder (MOLP) concentration increased, the breaking force decreased, while the thickness reduced and the 3% MOLP snack prototype was the thinnest.

Table 4.2: Effect of *Moringa oleifera* leaf powder (MOLP) on the texture of wheat-maize snacks

Snack type	Breaking force (g)	Thickness (mm)
0% MOLP* (control)	2,284.78 ± 861.71^{ab}	12.87 ± 1.66^{a}
1% (7.4 g) MOLP	2,126.79 ± 431.59^{a}	12.18 ± 2.11^{a}
3% (14.8 g) MOLP	1,635.36 ± 470.98^{a}	11.78 ± 1.03^{a}
5% (36.9 g) MOLP	1,459.76 ± 476.22^{ac}	12.12 ± 0.71^{a}

Means ± SD. Mean values followed by different superscript letters in the same column are significantly different at $p<0.05$, determined by Tukey test. MOLP*: *Moringa oleifera* leaf powder.

4.6.3 Nutritional composition of raw ingredients and MOLP snack prototypes

The results of this study showed that wheat flour had the highest moisture content, the total mineral content (ash) was highest in MOLP, the fat content was highest in maize meal, the fibre content (Acid Detergent Fibre and Neutral Detergent Fibre) was highest in MOLP as well as the crude protein content (Table 4.3). The 1% (7.4 g) MOLP snack was the prototype that was analyzed for nutritional composition because it was more acceptable to consumers during sensory evaluation (Table 4.5). The moisture content was higher in the 1% MOLP snack prototype then in the control, ash was higher in the 0% (control) MOLP snack, as well as fat content. The fibre content of ADF was similar for both snack prototypes (0% and 1% MOLP), the NDF was higher for the control snack. The 1% MOLP snack had higher crude protein content, when compared with the control. There was no significant difference for nutritional composition in raw ingredients and in the 1% MOLP snack prototype, except for ADF and NDF ($p<0.05$) in comparison to the control. There was no significant difference between the control (0% MOLP) snack and maize meal with respect to moisture, ash, fat, ADF, NDF, and crude protein. There was also no significant difference between the control (0% MOLP) and 1% MOLP snack prototypes in terms of fibre (ADF and NDF) content.

Table 4.3: Effect of *Moringa oleifera* leaf powder (MOLP) on the nutritional composition of wheat-maize snacks

Sample	Moisture	Ash	Fat	ADF	NDF	Crude Protein
	%	(g/100g)				
MOLP*	9.92 ± 0.22^{b}	12.3 ± 0.15^{b}	7.12 ± 1.22^{b}	14.51 ± 1.55^{b}	17.81 ± 0.97^{a}	29.25 ± 0.12^{b}
Wheat flour	15.11 ± 0.62^{c}	1.46 ± 0.26^{c}	1.55 ± 0.07^{c}	2.23 ± 0.30^{c}	8.19 ± 0.76^{b}	14.47 ± 0.16^{c}
Maize meal	1.68 ± 0.01^{a}	2.70 ± 0.04^{a}	22.62 ± 0.49^{a}	4.19 ±0.16^{a}	15.17 ± 0.39^{a}	9.47 ± 0.28^{a}
1% (7.4 g) MOLP	13.68 ± 0.14^{d}	1.35 ± 0.31^{e}	3.79 ± 0.76^{d}	4.36 ± 0.49^{a}	14.48 ± 1.00^{a}	10.57 ± 0.18^{d}
0% MOLP (control)	2.64 ± 0.17^{a}	2.48 ± 0.06^{a}	22.46 ± 0.83^{a}	4.91 ± 0.44^{a}	16.17 ± 0.67^{a}	9.76 ± 0.16^{a}

Means ± SD. Mean values followed by different superscript letters in the same column are significantly different at $p<0.05$, determined by Dunnet test. MOLP*: *Moringa oleifera* leaf powder.

Moringa oleifera leaf powder (MOLP) had the highest mineral content for Ca, Mg, K, P, Mn and Fe; when compared to wheat flour and maize meal as shown in Table 4.4. Maize meal had the highest Zn content among raw ingredients that were used for the development of MOLP snack prototypes. The 1% (7.4 g) MOLP snack prototype had the highest content of Ca, Mg, K and Fe in comparison to the control (0% MOLP). There were similar amounts of P, Zn and Mg between the control (0% MOLP) and 1% MOLP snack prototypes. There was no significant difference between the control, wheat flour, maize meal and 1% (7.4 g) MOLP snack prototype for Ca; Mg; Mn and Fe content. There was no significant difference between the control, wheat flour and maize meal with respect to K content, similar results were obtained for Zn. For P there was no significant difference between the control and maize meal. Lastly, there was no significant difference for Mn between maize meal, 1% MOLP snack prototype and the control (Table 4.4).

4.7 Consumer acceptability of *Moringa oleifera* leaf powder (MOLP) snack prototypes

To achieve objective three of this study consumer acceptability of MOLP snack prototypes was conducted and the results are shown in Table 4.5. The colour for the 5% (36.9 g) MOLP snack had a mean score of 2.6 which means it was disliked lightly in comparison to the control (0% MOLP). The colour for snack prototypes with 1% (7.4 g), 3% (14.8 g) MOLP as well as the control (0% MOLP) had average mean scores which means that their colours were neither liked nor disliked. The aroma for all the snack prototypes was neither liked nor disliked including the control (0% MOLP). The sensory attributes of taste and crunchiness were neither liked nor disliked by the panelists for all snack prototypes. For overall acceptability, the control (0% MOLP), 1% (7.4 g) MOLP snack and 3% (14. 8g) MOLP snack had average mean scores, indicating that they were neither accepted nor unaccepted. The snack prototype with 5% (36.9 g) MOLP was slightly unaccepted because it had a mean score of <3. It can be concluded that the 1% MOLP snack prototype was acceptable as the control by caregivers for all sensory attributes.

Table 4.4: Effect of *Moringa oleifera* leaf powder (MOLP) on mineral content of wheat-maize snacks

Sample	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Phosphorus (P)	Zinc (Zn)	Manganese (Mn)	Iron (Fe)
			(mg/100 g)				
MOLP*	2.18 ± 0.06^{b}	0.70 ± 0.01^{b}	1.31 ± .02^{b}	0.30 ± 0.01^{b}	17.0 ± 1.41^{a}	61.0 ± 1.41^{b}	593.0 ± 86.27^{b}
Wheat flour	0.02 ± 0.00^{a}	0.03 ± 0.00^{a}	0.16 ± 0.00^{a}	0.14 ± 0.00^{c}	9.0 ± 0.00^{a}	9.0 ± 0.00^{c}	10.5 ± 2.12^{a}
Maize meal	0.00 ± 0.01^{a}	0.08 ± 0.01^{a}	0.30 ± 0.00^{a}	0.23 ± 0.01^{a}	22.0 ± 1.41^{a}	7.0 ± 0.00^{a}	21.0 ± 1.41^{a}
1% (7.4 g) MOLP	0.07 ± 0.00^{a}	0.05 ± 0.00^{a}	0.19 ± 0.01^{c}	0.34 ± 0.00^{d}	13.0 ± 1.41^{b}	6.0 ± 0.00^{a}	40.0 ± 0.00^{a}
0% MOLP (control)	0.05 ± 0.00^{a}	0.04 ± 0.00^{a}	0.18 ± 0.01^{a}	0.34 ± 0.00^{a}	13.0 ± 1.41^{a}	6.0 ± 0.00^{a}	25.0 ± 0.00^{a}

Means ± SD. Mean values followed by different superscript letters in the same column are significantly different at $p<0.05$, determined by Dunnet test. MOLP*: *Moringa oleifera* leaf powder.

Table 4.5: Effect of *Moringa oleifera* leaf powder (MOLP) on consumer acceptability of wheat-maize snacks (N=60)

Sample	Colour	Aroma	Taste	Crunchiness	Overall Acceptability
1% (7.4 g) MOLP*	3.8 ± 1.0[a]	3.6 ± 1.1[a]	3.3 ± 1.2[a]	3.6 ± 1.1[a]	3.6 ± 1.3[a]
3% (14.8 g) MOLP	3.6 ± 1.1[a]	3.5 ± 1.1[a]	3.2 ± 1.1[a]	3.4 ± 1.1[a]	3.4 ± 1.3[a]
5% (36.9 g) MOLP	2.6 ± 1.5[b]	3.3 ± 1.3[a]	3.0 ± 1.2[a]	3.2 ± 1.2[a]	2.9 ± 1.5[b]
0% MOLP (control)	3.8 ± 1.2[a]	3.6 ± 0.9[a]	3.3 ± 1.2[a]	3.4 ± 1.2[a]	3.6 ± 1.3[a]

Means ± SD. Mean values followed by different superscript letters in the same column are significantly different at $p<0.05$, determined by Dunnet test. Mean score < 3 = dislike; mean score 3 = neither like nor dislike; mean score > 3 = like. MOLP*: *Moringa oleifera* leaf powder.

4.8 Focus group discussions

Focus group discussions were conducted with caregivers as shown in Tables 4.6 and 4.7, to obtain their perceptions on the food and nutrition status of their children as well as towards *Moringa oleifera* leaf powder (MOLP) to achieve objective four of this study. It was evident from responses given in focus group discussions that children in Ntambanana were faced with food and nutrition insecurity because access to food depended on socio-economic status and there was also disproportionate access or utilization of food in households. The focus group discussion results also indicated that even though caregivers were unfamiliar with *Moringa oleifera* leaf powder they were willing to give MOLP based snacks or foods to children.

Table 4.6: The perception of caregivers towards the food and nutrition status of children

Question	Theme/s	Direct quotes
Would you say that children of Ntambanana are food and nutrition secure?	**Food access:** socio-economic status and household family size	*"It is not the same, depends on the household size and employment status of household members which determines affordability of food"*

Table 4.6: The perception of caregivers towards the food and nutrition status of children cont.

Question	Theme/s	Direct quotes
How do households cope with food and nutrition insecurity, especially in children?	**Indirect food deprivation for parents especially mothers:** less portions, skipping of meals and relying on home gardens	*"Parents give their children from 6 months' tea, amahewu and concentrated juice"* *"Rely on vegetables (spinach, cabbage) from household garden"* *"I would ask for my husband and I to go on fasting, so that our children can eat whatever is available"* *"Mothers go to bed hungry so that their children can eat but fathers never sleep hungry even if it means children don't eat so that he can eat"*
What is your understanding of snacking for children?	**Food utilization:** application of proper or improper nutritional knowledge	*"Children demand snacks"* *"To add nutrients to their diet"*

Table 4.7: The perception of caregivers towards *Moringa oleifera* leaf powder

Question	Theme/s	Direct quotes
Perceptions about *Moringa oleifera* leaf powder	Less popular and inadequate knowledge	*"We don't know anything about Moringa oleifera* leaf powder*"* *"I only know that the trees were planted for bio-fuel production"*
Utilization of *Moringa oleifera* leaf powder in snacks or foods for children under 5 years	*Moringa oleifera* acceptability based on further access to nutritional knowledge	*"Yes, after learning more about Moringa oleifera* leaf powder *we can give it to our children under 5 years"*

CHAPTER 5: DISCUSSION OF RESULTS

5.1 Introduction

Chapter five is about the discussion of results found in this study in relation to relevant studies, for comparison and contradiction of findings.

5.2 Socio-demographic information

Statistics South Africa (2013) reported that individuals older than 18 years who had no formal education, experienced higher levels of poverty when compared to those who obtained primary; secondary and tertiary education. According to Ntambanana IDP (2013/14) the unemployment rate was found to be 49.2% and the results of this study found a rate of 76%. Unemployment is a contributing factor to food insecurity (Altman *et al.,* 2009; Manyamba *et al.,* 2012). Contradictorily, a study by Dodd & Nyabvudzi (2014) reported that participants who were unemployed were food secure due to agricultural production.

According to Stats SA (2014) the provision of social grants has been reported to reduce poverty levels in South Africa. However, this was not the case in Ntambanana because the community was still faced with challenges of poverty and this was confirmed by a food poverty line that ranged from R133.50-R250.00 which is lesser than the South African food poverty line of R335.00 (per person per month). This range was obtained by calculating the poverty line based on the average source of income (R801.00-R1500.00) divided by the average household size of six members (Ntambanana IDP, 2013/14; STATS SA, 2015). Based on the results of this study, children in Ntambanana are faced with poverty which is a contributing factor to food and nutrition insecurity that leads to malnutrition because their parents or caregivers have no formal education, are unemployed and the pension grants they receive from government is not reducing poverty because they still fall below the poverty line. Considering that more than half the children

in this study were one year old's, creates a concern since Da Cunha *et al,* (2015) and a 2012 report by Save the children organization stated that the first 1000 days of life for children are the most crucial for proper growth and development.

5.3 Snacks given to children

Huffman *et al,* (2014) reported that processed snack consumption was increasing in low and middle income countries and South Africa is no exception because a study by Ronquest-Ross *et al,* (2014) reported that the consumption of savoury and sweet snacks increased with a percentage of 53, from 1999 to 2012. Savoury and sugary snacks were classified by WHO (2005) as unhealthy because they are high in salt and sugar content. A daily consumption of salty and sugary snacks by children, could make them susceptible to diseases of lifestyle at an early stage in life. In the savoury category of snacks Govender (2016) found similar results to this study, where Jiggies were amongst the snacks given to children.

WHO (2005) defined snacks as foods eaten between meals which are usually self-fed, convenient and easy to prepare. The results of this study indicated that children were given snacks at lunch and at breakfast of which is contrary to this definition. Contributing factors to this contradiction could be a lack of nutritional knowledge that caregivers have about the concept of snacking or because of the age of children. A study by Fisher *et al,* (2014) found that mothers could not make a clear differentiation between snacks and "real foods".

Interesting findings were that when caregivers were asked what kind of snacks they introduced to children in age categories of between one and five years, what was evident was that healthy snacks as categorized by WHO (2005) were given less frequently to children and unhealthy snacks were given more frequently. These results also signify that caregivers cannot clearly distinguish

between healthy and unhealthy snacks, otherwise they would give children more healthy snacks. These findings are contradictory to Fisher *et al,* 2014 findings where mothers knew about good and unhealthy snacks but choose to give snacks to children depending on environmental factors, for example, at home children were given fruit like bananas, apples, and grapes but in public, mothers gave children chips, juice, cakes, and candy. The reasons that were mentioned by mothers in a study by Fisher *et al,* (2014) were like the findings of this study which were emotionally and circumstantially inclined rather than nutrition based.

5.4 Vegetable consumption with meals

Leafy vegetables, tend to be the most metabolically active and most nutritious part of plants and are usually good sources of dietary fibre, folacin, carotenoids, vitamin C, flavonoids, and minerals such as iron, zinc, calcium and magnesium (Adams, 2013; Slavin & Lloyd, 2012). Serrano & Powell (2013) recommended that children should obtain either two to three servings of vegetables per day, the results of this study were in accordance with this recommendation. A lack of food gardens can be another contributing factor to food and nutrition insecurity in Ntambanana because home gardens can contribute to household food security as reported by a case study about Three Villages in Nkonkobe Municipality - Eastern Cape, conducted by Adekunle (2013) and Galhena (2012) also found that home gardens contributed to food security, income generation and livelihoods in the Northern region of Sri Lanka.

5.5 Utilization of *Moringa oleifera* leaf powder (MOLP)

The *Moringa oleifera* tree plantation project started in the year 2013 in Ntambanana as a strategy by local government to enhance food security in the community (Ntambanana IDP, 2015/16), but the results of this study have shown that people in the community are not familiar with MOLP. There is a possibility that the minority of 10% that knew about MOLP were members of the

farmers' co-operative formed in the community and which works with the Department of Agriculture at Luwamba centre. A study by Farinola *et al,* (2014) found that participants found information about *Moringa oleifera* from friends, family, health practitioners and from either print or electronic media, in comparison to the participants of this study who only had information about *Moringa oleifera* from a singular source.

The South African Department of Agriculture, Forestry and Fishery (2013) has classified *Moringa oleifera* as a medicinal plant and it is also the same in Nigeria as reported by Kola-Oladiji *et al,* (2014). Nonetheless in Limpopo (South Africa), a project called the "Lammangata project" was launched in 2009, where *Moringa oleifera* leaf powder was incorporated into children's food at a drop-in centre that fed 347 children, including 87 children who were orphans. A decrease in the malnutrition rate was noted by the workers at the centre (Lekgau, 2012). All participants in the study conducted by Agyepong (2009) were willing to be introduced to *Moringa oleifera* leaves as a green leafy vegetable that could be added to their dishes, these results are like the findings of this study. A study by Kola-Oladiji *et al,* (2014) showed that participants were willing to utilize MOLP after they were educated about it. A study by Manaois *et al,* (2013) showed that respondents were willing to purchase rice crackers fortified with MOLP after they learnt about its nutritional value.

5.6 Food product development discussion

The low L* values are an indication of the darkening colour of the snacks which can be due to the extent of browning reaction such as the Maillard reaction (Leonel *et al.,* 2009). The dark green colour as indicated by low a* values of snacks can be attributed to the addition of *Moringa oleifera* leaf powder (MOLP) which has chlorophyll pigmentation. A similar trend was also reported by Abdela-shafi & Abdulla (2014) for cookies and Daniso (2015) for extruded Amaranth-enriched provitamin A-biofortified snacks.

The change in breaking force of the tortilla snack prototypes could be attributed to the dilution of gluten. There was lower water availability for the hydration of gluten as the MOLP increased in the dough mixtures. Texture can also be affected by cooking temperature, time and smooth particle size of ingredients utilized which absorb more oil as the water evaporates thus also causing blisters that formed on the snack prototypes (Abdela-shafi & Abdulla, 2014; Moreira *et al.,* 1997). The results of this study for breaking force were contrary to those reported by Dachana *et al,* (2010) which were 4.58 g, 5.15 g, 6.35 g, and 7.84 g for cookies that had MOLP incorporated at 0%, 5%, 10% and 15%, respectively.

The crude protein content of *Moringa oleifera* leaf powder (MOLP) for this study was within the range (19-30%) reported in studies conducted in Thailand, Brazil and South Africa by Jongrungruangchok *et al,* (2010); Teixeira *et al,* (2014) and Moyo *et al,* (2011), respectively. The total mineral content (ash), Iron (Fe) and fat in MOLP used for this study was found to be higher than that reported by Jongrungruangchok *et al,* (2010) but Calcium (Ca) and Potassium (K) contents were lower. A study by Moyo *et al,* (2011) conducted in South Africa on MOLP found contrary results to this study except for almost similar results for moisture and Phosphorus (P).

The results of this study for nutritional composition of local maize (unfortified) were contradictory from studies conducted by Pillay *et al,* (2013); Govender (2014) and Daniso (2015) in that moisture and protein contents were lower while fat, Iron (Fe) and Zinc (Zn) contents were higher. When comparing the nutritional composition of purchased and fortified wheat flour that was used in this study, it was evident that wheat flour utilized in this study had lower amounts of nutrients then the wheat flours used by Nuss *et al,* (2010); Malomo *et al,* (2011); and Ragaee *et al,* (2005), except for Manganese (Mn), Iron (Fe), Zinc (Zn), fat and protein. These contrary results might be due to genetic or environmental factors.

The 1% *Moringa oleifera* leaf powder (MOLP) snack prototype developed in this study had more ash and crude protein in comparison to Abdela-shafi & Abdulla's (2014) study, even though their study used more MOLP (3%). The same study reported comparable results found in this study on the effect of MOLP on mineral content of wheat cookies. The minerals that increased in the 1% MOLP snack prototype in comparison to the control (0% MOLP) were Calcium (Ca), Magnesium (Mg), Potassium (K), and Iron (Fe), but Phosphorus (P) was similar for both prototypes. This trend was in accordance even though different percentages of MOLP were used for both studies.

The calcium content for the 1% (7.4 g) MOLP snack prototype used in this study was found to be less in comparison to the 1% (5 g) *Moringa oleifera* crushed leaves snack developed by Govender (2016). Thus, meaning the one 1% MOLP snack prototype for this study had less Calcium (Ca) while more MOLP was used, this could be attributed to the different nutrient analysis methods that were performed in these studies and the different forms of MOLP used. The Iron (Fe) and Zinc (Zn) content for this study was higher in the 1 % (7.4 g) MOLP snack compared to findings by Govender (2016).

5.7 Consumer acceptability of snack attributes

The results of this study for overall acceptability were like those reported by Alam *et al,* (2014), where biscuits with 1% Tulshi and MOLP were more acceptable. Kolawole *et al*, (2013) and Dachana *et al,* (2010) found that products with MOLP were acceptable but acceptability was for samples that had MOLP content of up to eight percent for cakes and ten percent for cookies, respectively. Contrary results were found by Kar *et al,* (2013) where MOLP biscuits were unacceptable compared to market biscuits (control).

CHAPTER 6: LIMITATIONS, CONCLUSION AND RECOMMEDATIONS

6.1 Introduction

This chapter presents the study limitations, a conclusion for this study that is made based on the results and recommendations for various stakeholders are also included.

6.2 Study limitations

6.2.1 The study was limited to Buchanana community, because that is where *Moringa oleifera* trees were planted. As a result, the findings of the study will not be generalizable to rural areas in Ntambanana and other communities.

6.2.2 Caregivers of children between the ages of one to five years were panelists for sensory evaluation of *Moringa oleifera* leaf powder snack prototypes because *Moringa oleifera* leaf powder has not been approved for human consumption, after a thorough explanation caregivers gave informed consent which serviced as an agreement.

6.2.3 Nutritional analysis of prototypes was limited to individual minerals, ash, crude protein, fibre (ADF and NDF), and fat. Vitamin analysis was not performed due to financial constraints.

6.2.4 The type of *Moringa oleifera* leaf powder (MOLP) utilized for this study was purchased from a local supplier (Supa Nutri) and it was not MOLP from the study area.

6.3 Conclusion

Literature has shown that children are faced with nutritional challenges. The consumption of unhealthy snacks laden with sugar, fat and salt which are affordable contribute to undernutrition. Food-based strategies tailor made for children could be effective in improving children's nutritional status. The results of this study showed that among the snacks that were

mostly given to children, savoury snacks were given daily and the consumption increased with age. While healthy snacks were consumed less with age. Caregivers gave children snacks from an emotional perspective rather than from a nutritional perspective. There was also a connection between the socio-demographic results and focus group discussions, where it was evident that children from Ntambanana were faced with food and nutrition insecurity.

Vegetables were not given to children as snacks, thus it could be feasible to incorporate *Moringa oleifera* leaf powder into snacks to fill this gap. Even though most caregivers in Ntambanana were not familiar with *Moringa oleifera* leaf powder while it is available in the community, there was a willingness to incorporate *Moringa oleifera* leaf powder into snacks for their children. The development of *Moringa oleifera* leaf powder snacks was based on the concept of making a snack that caregivers could easily make at home using basic household ingredients, feasible cooking method and be attractive to children. Four prototypes of snacks were developed with varying percentages of *Moringa oleifera* leaf powder (MOLP) at 0% (control), 1%, 3% and 5%. The consumer acceptability results showed that the 1% MOLP snack prototype was more acceptable after the control.

Quality assessments of colour, texture and nutritional composition showed that the colour of the snack prototypes became greener with increasing fortification of MOLP, the texture of the snack prototypes decreased with increasing MOLP concentration. Since the 1% MOLP snack prototype was more acceptable for all sensory attributes, it was analyzed for nutritional composition in comparison to the control. The 1% MOLP snack prototype was of higher quality then the control (0%) snack prototype based on results for individual minerals, this could be attributed to the quality of MOLP that was used in comparison to maize and wheat as raw ingredients. The 1% MOLP snack prototype had less fat, and more crude protein content in comparison to the control. The improved nutritional composition of the 1% MOLP snack prototype versus the control indicates that there is a possibility that MOLP snacks could contribute to food and nutrition security for children but more research is needed to increase acceptability and improve food products fortified with MOLP.

6.4 Recommendations

6.4.1 Recommendations for future research

a) Researchers should investigate methods of reducing the intensity of the green colour imparted by *Moringa oleifera* leaf powder (MOLP) onto food products.

b) The effects of cooking method, time, and temperature on the quality of food products developed from MOLP should be examined.

c) Food flavourings that can mask the grassy or herby taste of *Moringa oleifera* leaf powder in food should be considered.

d) From the results of the study it was evident that snack prototypes with *Moringa oleifera* leaf powder had higher moisture content in comparison to the control, this requires further research in relation to packaging and storage quality.

e) Studies on pre- and post-tests of blood biochemistry should be conducted to determine if consumption of *Moringa oleifera* leaf powder in food products improves nutritional status.

f) A recipe book should be developed which incorporates *Moringa oleifera* leaf powder into basic and familiar foods that people consume followed by a succession of sensory evaluations.

6.4.2 Recommendations for government

a) Nutrition education about this “miracle tree” needs to be conducted by the Department of Health and related stakeholders in the food industry to create more awareness about *Moringa oleifera* leaf powder as a source of food.

b) *Moringa oleifera* seeds should also be provided or subsidized for small-holder farmers by the Department of Agriculture, Forestry and Fisheries.

c) Once *Moringa oleifera* leaf powder has been approved for human consumption, regulatory laws should be set for acceptable levels of fortification and food products sold in the market should be monitored and checked if they contain the correct type of Moringa, which is *Moringa Oleifera.*

d) If food products developed by incorporating *Moringa oleifera* leaf powder are not acceptable to the public, they could be developed as part of food aid for countries faced with famine, natural disasters and wars.

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APPENDICES

Appendix A: The suite of food security indicators (FAO, 2013).

Food security indicators	Dimension
*Average dietary energy supply adequacy *Average value of food production *Share of dietary energy supply derived from cereals, roots and tubers *Average protein supply *Average supply of protein of animal origin	**AVAILABILITY**
*Percentage of paved roads over total roads *Road density *Rail lines density *Gross domestic product per capita (in purchasing power equivalents) *Domestic food price index *Prevalence of undernourishment *Share of food expenditure of the poor *Depth of the food deficit *Prevalence of food inadequacy	**ACCESS**
*Access to improved water sources *Access to improved sanitation facilities *Percentage of children under 5 years of age affected by wasting *Percentage of children under 5 years of age who are stunted *Percentage of children under 5 years of age who are underweight *Percentage of adults who are underweight *Prevalence of anaemia among pregnant women *Prevalence of anaemia among children under 5 years of age *Prevalence of vitamin A deficiency in the population *Prevalence of iodine deficiency in the population	**UTILIZATION**
*Cereal import dependency ratio *Percent of arable land equipped for irrigation *Value of food imports over total merchandise exports *Political stability and absence of violence/terrorism *Domestic food price volatility *Per capita food production variability *Per capita food supply variability	**STABILITY**

Appendix B: English Informed Consent

My name is Nozipho Zungu and I am a full-time student at the University of KwaZulu Natal registered for Masters in Agriculture (Food Security). I would like you to participate in this study which is about Assessing Nutritional Quality and Consumer Acceptability of *Moringa oleifera* Leaf Powder Based-Snacks for Improved Children's Food and Nutrition Security. Therefore, you will be required to participate in a survey, sensory evaluation of the *Moringa oleifera* snacks and in focus group discussions.

It is essential to know that:

- Participation in this study is voluntary, you can stop participating at any time during the study
- There will be no form of payment for participating in the study
- All information will be kept confidential and will only be used for the purpose of this study
- Over time the information provided will be destroyed when deemed necessary
- For further information about the study, please contact my supervisor Dr Van Onselen at vanonselen@ukzn.ac.za

Declaration

I _____ (full name and surname) hereby confirm my understanding of the questionnaire and I understand that I will not be exposed to any risks during the study and that I may withdraw from participating at any point.

_____ _____

Signature Date

_____

Phone number

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Appendix C: IsiZulu informed consent

Igama lami ngingu Nozipho Zungu, ngingumfundi e Nyuvesi yaKwazulu-Natal, ngenza I Masters kwi Agriculture noma kwezolimo (food security). Ngingathanda ukuthi ube yingxenye yalolu cwaningo mayelana nokwamukeleka kokudla okwenziwe ngempuphu yamaqabunga e-*Moringa oleifera.* Lokhu kusho ukuthi uzodingeka ukuba unambithe ukudla okwenziwe nge-Moringa bese ukhombisa imibono yakho mayelana nokunambitheka, ukuzwakala emlomeni, umbala kanye nokukwamukela kwakho kokudla jikelele.

Kubalulekile ukuthi wazi okulandelayo

- Ukuze ube ingxenye yalolucwaningo kungenxa yokuvolontiya kwakho, uvumelekile ukuthi uyeke phakathi kocwaningo uma ufisa, akukho lutho olubi oluzokwenziwa kuwe.
- Ayikho imali ezoyithola uma uba yingxenye yalolucwaningo.
- Imininingwane ezotholakala izosebenziswa kulolucwaningo kuphela. Futhi izogodlwa ngokuphephile esikhungweni seNyuvesi.
- Yonke imininingwane yalolucwaningo izolahlwa uma ingasadingeki
- Uma udinga eminye imininingwane ngalolucwaningo ungathintana no Dr Van Onselen ongumphathi walolucwaningo. Utholakala la vanonselen@ukzn.ac.za

Izwi lobufakazi:

Mina…… (Amagama aphelele nesibongo) ngiyaqiniseka ukuthi ngichazelekile kahle ngalemibuzo engizobuzwa yona futhi ngiyasiqonda isizathu salolucwaningo nokuthi yonke imininingwane etholakele izohlolwa. Ngiyavuma ukuba ingxenye yalolu cwaningo, ngiyaqonda ukuthi kuyavolontiywa ukuba ingxenye yalolucwaningo nanokuthi ngingashiya phakathi uma ngifisa

…… ……..

Sayina Usuku

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Appendix D: Survey questionnaire (English)

D1: Socio-Demographic Information

1. Gender

1	Male	
2	Female	

2. Age of participant

1		

3. What is your role to children in the household?

1	A parent	
2	A relative	
3	A guardian	
4	A house-worker or maid	
5	Other (Specify)	

4. How many are you in the household?

1		

5. How many rooms are in the household?

1		

6. How many children do you have in the household between the ages of?

1	1-5 years	

7. Level of Education

1	No formal education	
2	Primary	
3	Secondary	
4	Tertiary	

8. Employment status

1	Employed full time	
2	Employment part time	
3	Self – employed	
4	Unemployed	

9. Source of income

1	Wages	
2	Salary	
3	Pension	
4	Grant	
5	Other (specify)	

10. Total household income per month

1	Below 800	
2	R801 – R1500	
3	R1501 – R3500	
4	Above R3500	

11. How many times do children experience diarrhoea?

1	Less than three times a week	
2	Three times or more a week	
3	Never	

12. How many times do children experience constipation?

1	Less than three times a week	
2	Three times or more a week	
3	Never	

D2: Snacks mostly given to children

1. Do you give children snacks?

1	Yes	
2	No	

2. If yes, which snacks do you mostly give to children? List them and the serving size

	List them here	**Indicate the serving size**
1		
2		
3		
4		
5		
6		
7		
8		

3. How often are children given snacks?

1	Seldom	
2	Everyday	
3	Once a week	
4	Only on weekends	
5	Other	
6	Specify if you have chosen 'other'	

4. When are the snacks given and which type?

		Types of snacks
1	Breakfast	
2	Midmorning	
3	Lunch	
4	Mid-lunch	
5	Dinner	
6	After dinner	
7	Other (specify)	

5. What kind of snacks do you introduce to a child of age? List the snack

		Types of snacks
1	1 year - 2 years	
2	More than 2 years – 3 years	
3	More than 3 years – 4 years	
4	More than 4 years – 5 years	

6. Why do you give children snacks?

1		
2		
3		
4		
5		

7. How much is spent on snacks per child, per week?

1	R0	
2	R0, 50 – R2	
3	More than R2 – R5	
4	More than R5 – R10	
5	More than R10	

8. What is the deciding criteria for buying a particular type of snack for your child?

1		
2		
3		
4		

9. Do you give vegetables to children?

1	Yes	
2	No	
3	Sometimes	

10. If yes, list vegetables that are mostly given to children

1		
2		
3		
4		

11. How many servings of different vegetables do you give to children per day?

		List them
1	1 serving of a single kind of vegetable in a day	
2	2-3 servings of different kinds of vegetables per day	
3	4-5 servings of different kinds of vegetables per day	

12. Do you have a garden at home?

1	Yes	
2	No	

13. Which vegetables do you grow in your garden? List them

1		
2		
3		
4		
5		
6		

D3: Utilization of *Moringa oleifera*

1.1 Are you familiar with Moringa?

1	Yes	
2	No	

1.2 If yes, where did you get information?

_____
_____

2. If yes, in what form have you used Moringa?

1	Fresh (leaves, roots, seeds)	
2	Powdered leaf form	
3	Powdered seeds	

3. Do you use Moringa for the following/s? Please tick

		Yes	No
1	For strength/wellbeing		
2	For stamina/performance		
3	To aid digestion		
4	To stimulate appetite		
5	For skin problems		
6	For stomach pains		
7	Other (Specify)		

4. How often do you take Moringa?

1	Frequently- at least three times per week	
2	Regularly- at least once a week	
3	Occasionally – at least once a month	
4	Never	

5. Are you familiar with the use of Moringa in food?

1	Yes	
2	No	

6. If yes, how do you use Moringa in food? Tick all that applies to you

		Yes	No
1	Use it as tea		
2	Take it as soup		
3	Take as part of a vegetable dish		
4	Taken as part of meat dish		
5	Sprinkle in ready to eat food		
6	Sprinkle while cooking		
7	Other (Specify)		

7. If no, when encouraged to use Moringa as food for nutritional benefits would you…? Tick only the one that applies to you.

1	I would happily use it	
2	I would try it at least once	
3	I am not sure	
4	I would not use it	

8.1 Have you ever given Moringa to a child?

1	Yes	
2	No	

8.2 If yes, specify in what form?

_____

_____

9.1 Would you be willing to include Moringa in the current snack for your child?

1	Yes	
2	No	

9.2 If yes, for what benefit?

_____

_____

9.3 If no, then why not?

_____

_____

Appendix E: Survey questionnaire (IsiZulu)

E1: Imininingwane yomuntu oyingxenye yocwaningo

1. Ubulili

1	Ngingowesilisa	
2	Ngingowesifazane	

2. Ngabe uneminyaka emingaki?

1		

3. Buyini ubudlelwane bakho nezingane ezikhona endlini?

1	Ngingumzali	
2	Ngiyisihlobo	
3	Ngingumnakekeli	
4	Ngisebenza ukuthi nginakekele izingane	
5	Okunye (Chaza)	

4. Nibangaki enihlala endlini noma ebaleni elilodwa?

1		

5. Mangaki amagumbi endlu noma ezindlu ekhaya?

1		

6. Ingabe bangaki abantwana abaneminyaka ewu 1 kuya kwewu 5 ubudala ekhaya?

1	Abantwana abaneminyaka ewu 1 kuya kwewu 5	

7. Ufunde wagcina kumaphi amazinga esikoleni?

1	Angifundile	
2	Amazinga aphansi	
3	Amazinga aphakathi nendawo	
4	Amazinga aphezulu	

8. Ingabe uyasebenza?

1	Yebo – ngiqashiwe ngokuphelele	
2	Yebo – ngiqashiwe okwesikhashana	
3	Ngiyazisebenza	
4	Angiqashiwe	

9. Iholo olitholayo liphuma kuphi?

1	Etohweni	
2	Iholo elivela emsebenzini njalo ngenyanga	
3	Imali yempesheni	
4	Imila yesondlo sezingane	
5	Kwenye Indawo (Ibhale)	

10. Ingakanani imali engena njalo ngenyanga ekhaya?

1	Ingaphansi kuka R800	
2	R 801 – R1500	
3	R1501 – R3500	
4	Ingaphezuli kuka R 3500	

11. Ingabe ziphathwa kangaki isifo sohudo izingane evikini?

1	Ngaphansi kwezikhathi eziwu-3 evikini	
2	Izikhathi eziwu-3 noma ngaphezulu evikini	
3	Aziphathwa isifo sohudo	

12. Ingabe izingane ziphathwa ukusongelana kwesisu kangaki evikini?

1	Ngaphansi kwezikhathi eziwu-3 evikini	
2	Izikhathi eziwu-3 noma ngaphezulu evikini	
3	Azisongelwa neze isisu	

E2: Izidlo ezincanyana ezidliwa izingane

1. Ingabe uyazinikeza izingane izidlo ezincanyana (phecelezi ama - snacks)

1	Yebo	
2	Chabo	

2. Uma impendulo ithi yebo, iziphi izidlo ezincanyana ojwayele ukuzinikeza zona? Zibhale ngensansi, ubhale nenani obanika lona

	Zibhale la	**Bhala inani**
1		
2		
3		
4		
5		
6		
7		
8		

3. Uzinika kangaki izingane izidlo ezincanyana?

1	Ngizinikeza nje	
2	Ngizinikeza nsuku zonke	
3	Ngizinika kanye ngeviki	
4	Ngizinika ngempelasonto	
5	Iziphi ezinye izikhathi (zibhale)	

4. Ingabe uzinika ngasiphi isikhathi izingane izidlo ezincanyana futhi usuke ubanikeza yiphi inhlobo?

		Inhlobo yesidlo esincanyana
1	Uma ziqeda ukudla isidlo sasekuseni	
2	Phakathi kwesidlo sasekuseni nesidlo sasemini	
3	Uma ziqeda ukudla isidlo sasemini	
4	Phakathi kwesidlo sasemini nesidlo santambama	
5	Uma ziqeda ukudla isidlo santambama	
6	Ezinye izikhathi (zibhale)	

5. Ingabe uzinikeza ziphi izinhlobo yezidlo ezincanyana izingane ezineminyaka elandelayo?

		Izinhlobo zezidlo ezincanyana
1	Unyaka owodwa kuya kwemibili	
2	Iminyaka engaphezulu kwemibili kuya kwemithathu	
3	Iminyaka engaphezulu kwemithathu kuya kwemine	
4	Iminyaka engaphezulu kwemine kuya kweyisihlanu	

6. Ingabe iziphi izizathu ezenza unikeze NOMA uthengele izingane izidlo ezincanyana?

1		
2		
3		
4		
5		

7. Ngabe usebenzisa malini evikini uthengela ingane ngayinye izidlo ezincanyana?

1	R0	
2	R0, 50- R2	
3	Ngaphezu kuka R2 – R5	
4	Ngaphezu kuka R5 – R10	
5	Ngaphezu kuka R10	

8. Ingabe yini iziphi izizathu ezikwenza ukuba uthengele noma unikeze izingane izidlo ezincanyana?

1		
2		
3		
4		

9. Ingabe uyazinikeza izingane izitshalo (amaveji) ukuba zizidle?

1	Yebo	
2	Chabo	
3	Kwezinye izikhathi	

10. Uma impendulo ithi yebo, bhala izitshalo (amaveji) ojwayele ukuzinikeza zona izingane

1		
2		
3		
4		

11. Ingabe uzinikeza izinhlobo ezingaki zezitshalo ezahlukahlukene izingane?

		Zibhale
1	Isitshalo esiyi-1 senhlobo eyodwa	
2	Izitshalo eziwu 2 kuya kweziwu 3 zezinhlobo ezahlukahlukene zezitshalo	
3	Izitshalo eziwu 4 kuya kweziwu 5 zezinhlobo ezahlukahlukene zezitshalo	

12. Ingabe unayo insimu ekhaya?

1	Yebo	
2	Chabo	

13. Ingabe iziphi izitshalo ozitshalile ensimini yakho? Zibhale

1		
2		
3		
4		
5		
6		

E3: Ukusetshenziswa kwesitshalo i-*Moringa oleifera*

1.1 Ingabe uyasazi isitshalo i-Moringa?

1	Yebo	
2	Chabo	

1.2 Uma impendulo ithi yebo, ulwazi mayelana nayo waluthathaphi?

_____

_____

2. Uma impendulo ithi yebo, usuke wasebenzisa yiphi ingxenye ye Moringa?

1	Amaqabunga, izimpande, imbewu (oku-fresh)	
2	Amaqabunga agayiwe	
3	Imbewu egayiwe	

3. Ngabe i-Moringa uyisebenzisela lokhu okulandelayo yini? Shaya isiphambano maqondana nempendulo yakho

		Yebo	Chabo
1	Umdlandla		
2	Ukusongelana		
3	Ukuze ukwazi ukuthanda ukudla		
4	Ukuqeda izinhlungu emzimbeni		
5	Ekulapheni izinkinga zesikhumba		
6	Izinhlungu esiswini (phecelezi ama - ulcer)		
7	Okunye (Kubhale)		

4. Uyisebenzisa kangaki i-Moringa?

1	Kathathu evikini	
2	Kanye nge-viki	
3	Kanye ngenyanga	

5. Ngabe ujwayele yini ukusebenzisa i-Moringa ekudleni?

1	Yebo	
2	Chabo	

6. Uma impendulo ithi yebo, ngabe i-Moringa uyisebenzisa ukwenza kuphi ukudla? Shaya isiphambano maqondana nempendulo yakho

		Yebo	Chabo
1	Itiye		
2	Isobho		
3	Isishebo sezitshalo		
4	Isishebo senyama		
5	Ngiyivuvuzela ekudleni osekuvuthiwe		
6	Ngiyivuvuzela ekudleni okusaphekwa		
7	Okunye (kubhale)		

7. Uma impendulo ithi chabo, uma ungase ufundiswe ngokusebenzisa i-Moringa ekudleni ukuze uthole umsoco, ngabe ungayisebenzisa?

1	Ngingayisebenzisa ekudleni, ngenkulu intokozo	
2	Ngingayizama ukuyisebenzisa ekudleni, mhlape kanye	
3	Anginaso isiqiniseko	
4	Angeke ngiyisebenzise i-Moringa ekudleni	

8.1 Ngabe i-Moringa ungayifaka ekudleni kwezingane?

1	Yebo	
2	Chabo	
3	Angeke	

8.2 Uma impendulo ithi yebo, ungayisebenzisa isesimeni esinjani?

_____

_____

9.1 Ungayifaka yini i-Moringa ezindlwenu ezincanyana ezidliwa izingane?

1	Yebo	
2	Chabo	

9.2 Uma impendulo ithi yebo, ungayifaka ngobani?

_____

9.3 Uma impendulo ithi chabo, izithiphi izizathu ezingakwenza ukuba ungayifaki?

_____

_____

Appendix F: Standard recipe for flour tortillas (Bauer, 2015).

Preparation: 15 minutes Cooking time: 5 minutes Cooking temperature: 190 °C

Ingredients

4 cups all-purpose flour

1 teaspoon salt

2 teaspoons baking powder

2 tablespoons margarine

1 1/2 cups water

Method

1. Whisk the flour, salt, and baking powder together in a mixing bowl

2. Mix in the margarine with your fingers until the flour resembles cornmeal

3. Add the water and knead a few minutes until the dough comes together

4. Divide the dough into equal pieces and roll each piece into a ball

5. Place on a lightly floured surface, roll out using a well-floured rolling pin to roll a dough ball into a thin, round tortilla until flat and cut out eight triangles / wedges

6. Preheat the oil to 190 °C, stove number: 5

7. Add a handful of tortilla wedges at a time, turning over when golden brown.

8. Remove the chips with a slotted spoon and let drain on paper towels while you finish the remaining batches.

Appendix G: Sensory evaluation questionnaire (English) Respondent No: _____

Name of respondent: _____

Sample: _____

Date: _____

Instructions:

- Before tasting rinse the mouth with water, repeat rinsing after tasting each sample
- Taste from left to right
- MARK WITH AN **X** THE FACE THAT BESTS SUITS YOUR RESPONSE TO THE STATEMENTS BELOW

1. Colour

Dislike very much	Dislike slightly	Neither like nor dislike	Like slightly	Like very much

2. Aroma

Dislike very much	Dislike slightly	Neither like nor dislike	Like slightly	Like very much

3. Crunchiness

Dislike very much	Dislike slightly	Neither like nor dislike	Like slightly	Like very much

4. Taste

Dislike very much	Dislike slightly	Neither like nor dislike	Like slightly	Like very much

5. Overall Acceptability

Unacceptable very much	Unacceptable slightly	Neither acceptable nor unacceptable	Acceptable slightly	Acceptable very much

THANK YOU!!!!

Appendix H: Sensory evaluation questionnaire (IsiZulu) Umphenduli: _____

H1: Imibuzo yokwamukeleka kwezidlo ezincanyana ezenziwe nge-Moringa

Igama: ……

Inombolo yesampuli: …….

Usuku: ……..

Imiyalelo:

- ✓ Yakaza umlomo ngaphambi kokuba uqale. Uphinde uwuyakaze futhi uma usuhlola okunye ukudla
- ✓ Qala ngasesandleni sesinxele ukunambitha uye ngasesandleni sokudla
- ✓ Hlola ukudla okuphambi kwakho. Shono ukuthi ucabangani ngendlela okunambitheka ngayo, umbala, indlela okuzwakala ngayo emlonyeni kanye nendlela okuthanda ngayo njikelele
- ✓ **KHOMBISA LOKHU NGOKUSHAYA ISIPHAMBANO [X] PHEZU KOBUSO OBUQONDENE NOMUZWA WAKHO.**
- ✓ Uma unomubuzo ungabuza, ukhululeke

1. Umbala

Mubi impela	Mubi	Mhlawumbe mubi noma mhlawumbe muhle	Muhle	Muhle impela

2. Iphunga

Libi impela	Limbi	Mhlawumbe limnandi noma mhlawumbe	Limnandi	Limnandi impela

3. Ukunambitheka

Kubi impela	Kubi	Mhlawumbe kumnandi noma mhlawumbe kubi	Kumnandi	Kumnandi impela

4. Umsindo ozwakalayo uma udla

Mubi impela	Mubi	Mhlawumbe umnandi noma mhlawumbe mubi	Umnandi	Umnandi impela

5. Isinqumo jikelele (ukwamukeleka)

Kubi impela	Kubi	Mhlawumbe kumnandi noma mhlawumbe kubi	Kumnandi	Kumnandi impela

NGIYABONGA!!!!

Appendix I- Focus group discussion interview guide (English)

I 1: Food and Nutrition Security (Focus group discussion)

1. Would you say that children of Ntambanana are food and nutrition secure?
2. How do households cope with food and nutrition insecurity, especially in children?
3. What is your understanding of snacking in children?
4. Which snacks do you usually give to children?

I 2: Focus group discussion questions (*Moringa oleifera*)

1. Tell me what do you know about *Moringa oleifera* leaf powder?
2. How have you used it?
3. Do you think *Moringa oleifera* leaf powder can be good for children under 5 years?

Appendix J: Luwamba centre permission letter

Luwamba Rural Development Project

Reg as Global Precursor Projects
Reg No: 2007/072247/23
Supplier Reg No: GLOB 927 ZNT

61 Dryden Hall, 165 Ridge Rd
Durban 4001
Phone: 0716945894
Email: sbuagri@gmail.com

Date: 04 June 2015

Miss Nozipho Zungu
Student (Student number: 215079785)
African Centre for Food Security
University of KwaZulu-Natal
Private Bag X01
Scottsville
3209

RE: REQUEST TO CONDUCT RESEARCH ON CONSUMER ACCEPTABILITY OF *MORINGA OLEIFERA* LEAF POWDER-BASED SNACKS

Please be advised that you have been granted permission to conduct a research project on Consumer Acceptability of *Moringa oleifera* Leaf Powder-Based Snacks in Ntambanana. We understand that you will be conducting a community survey followed by sensory evaluations and focus group discussions with caregivers, who have children in pre-primary school.

We wish you well with your research

Yours Sincerely
Sbusiso Msimango

Appendix K: UKZN ethical clearance letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

04 February 2016

Ms Nozipho Zungu 215079785
School of Agricultural, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Ms Zungu

Protocol reference number: HSS/0781/015M
Project title: Assessing Nutritional Quality and Consumer Accessibility of a Moringa – based Snack in Ntambanana, KwaZulu-Natal.

Expedited Approval

In response to your application dated 25 June, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

Please note: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Dr Shenuka Singh (Chair)

/px

cc Supervisor: Dr U Kolanisi and Dr M Siwela
cc Academic Leader Research: Professor Onisimo Mutanga
cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
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